Meeting NASA's Needs with
Creativity and Innovation:

"TECH & TELL"

A FY'12 Report from the
JSC Office of the Chief Technologist

National Aeronautics and Space Administration
Johnson Space Center
Houston, Texas

www.nasa.gov and http://www.nasa.gov/centers/johnson/technologyatjsc/home

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Introduction and Overview

The Office of the Chief Technologist (OCT) has developed NASA's Space Technology Roadmaps to highlight the various technologies that are needed for NASA's missions as well as significant national needs. At the Center level, we understand that the Agency looks to its field centers to lead the development of many of these technologies, whether through our own innovation or in collaboration with industry and academic partners. Many of these relationships are managed, in part, by Center Chief Technologists (CCTs).

The Technology at JSC Logo

JSC's Chief Technologist works closely with the JSC's senior scientists, technologists and managers to sponsor and manage a substantial portfolio of technology projects along with a technology and innovation infrastructure that supports those projects. JSC's technology projects portfolio is guided by an informal technology strategy that maps to the overall JSC Strategic Implementation Plan in alignment with NASA's Strategic Plan. The overall goals of JSC's technology strategy are as follows:

Develop the Human Exploration Capabilities of Tomorrow

- Lead technology maturation efforts for human exploration
- Extend technology leadership in priority areas

Lead Advanced Development Collaborations on an International Scale

- Command partnering incentives that come from the ISS experience
- Promote effective co-developments with U.S. government and international partners, industry and academia

Excel in Technology Leadership, Management, and Innovation

- Evaluate innovative technical and business management practices
- Empower our workforce
- Emphasize the intellectual property/licensing outcomes of R&D investments

Maximize Relevance of Technology Outcomes to Life on Earth

- Promote R&D dual use developments supporting NASA and national needs
- Inspire the next generation
- Share the excitement

Continued vigilance in maintaining JSC competencies, capabilities, and a workforce skilled in their application is essential for NASA to remain a world-class hub for human space exploration. Our overall technology

Innovation 2012 at JSC

strategy was established to represent JSC's commitment to developing new technologies that support NASA's strategic goals.

Center Innovation Funds (CIF) are used by the JSC Chief Technologist's Office (JSC CTO) to support a substantial portion of JSC's portfolio of novel technologies that benefit NASA missions. These developments have the potential to address not only Center and Agency needs, but additional national needs as well.

The JSC Chief Technologist's Office

Organizationally, the JSC Chief Technologist is represented on JSC's senior staff and is supported by the JSC Technology Working Group (JTWG). The JTWG is a Center-level advisory body that supports JSC leadership in ensuring successful integration and coordination of Center research and technology development efforts and innovation initiatives. It consists of representatives from each of JSC's line organizations that engage in research and technology development along with representatives from JSC's External Relations Office (public affairs, education and university affairs), Strategic Opportunities and Partnership Development Office (technology transfer) and the Human Exploration Development Support Office (human spaceflight technology needs).

The JSC Chief Technologist's Office (JSC CTO) is made up of a small, but specialized group of skilled and creative individuals who are truly passionate about NASA and Johnson Space Center. They are equally passionate about supporting and promoting the continued advances in technology and innovation at the Center.

The JSC CTO's primary priority is to foster an environment of creativity at the center while ensuring that JSC's technology competencies align with Agency needs. The JSC CTO is in a unique position to encourage extreme amounts of creativity and innovation to ensure continuing development of the best technologies for future missions. JSC's principal investigators are reaching for better options, seeking alternative applications, and searching for new directions to solve problems and make further human space exploration not only achievable, but more cost effective without compromising safety and reliability.

The JSC CTO is JSC's connection to the NASA Office of the Chief Technologist. In September, OCT issued a charter for the Chief Technologist's Council *(ref. "Executed: CTC Charter Signature Version" correspondence from Joyce Rhym, dated September 5, 2012)* as an advisory body to the NASA Chief Technologist. Included in the charter was an updated set of CCT roles and responsibilities accountable to the following three stakeholders:

- The Chief Technologist of the NASA Office of the Chief Technologist (OCT)
- The Director of the OCT Space Technology Program (STP)
- The Center Director

In accordance with guidance received from the CIF Program Executive that "the majority of the report should spell out the achievements and accomplishments with an emphasis/explanation of how each activity was innovative and improve a culture of innovation at the Center" *(ref. "Final*

Report Deliverable" correspondence from Minoo Dastoor, dated August 28, 2012), the following two CCT responsibilities are highlighted below:

	Center Role	STP Role	OCT Role
• Manage the NASA Center Innovation Fund (CIF) at the field Center.	x	X	
• Serve as center change agent, particularly regarding the workforce's capacity to innovate	X		x

(note X, x = major, minor roles respectively)

With these responsibilities in mind, the JSC CTO leveraged the OCT CIF account with the Center Management and Operations (CM&O) Center Investments Account to support the following two categories of technology and innovation activities

Technology and Innovation Projects

- Center-Level Internal Research and Development (IR&D) Projects;
- Directorate-Level IR&D Projects; and
- Innovation Charge Account Studies

Technology and Innovation Infrastructure

- Facilities and Creative Spaces;
- Innovation Fairs and Symposia; and
- Workforce Initiatives

The details of each of these categories of activities is outlined in the following two sections.

Technology and Innovation Projects

Center-Level Internal Research and Development

For a number of cross-cutting technical areas, JSC continues to have co-existing silos of related activities. In addition, it's important to maintain a focus on R&D priorities held at the Center level. A Center-level IR&D account that promotes multi-organizational collaboration is one remedy to mitigate silos and emphasize Center-level priorities.

JSC Center-Level IR&D 2012 CIF Supported Project: Game Changing Augmented Reality Training and Assistance for Maintenance Repair by Lui Wang

Annual proposal calls are developed by the JTWG and coordinated with JSC Senior Staff and then communicated to the JSC workforce via internal email distribution and JSC Today notices. The JTWG vets and prioritizes the solicitation response in a two-stage process and then forwards a recommended IR&D portfolio to the JSC Chief Technologist for approval.

For 2012, the Center-Level IR&D proposal call was based on the intersection of the following priorities:

- Priority technology needs for Human Spaceflight;
- Priority core JSC technology competencies;
- High potential areas for technology commercialization; and
- High potential areas for technology partnerships

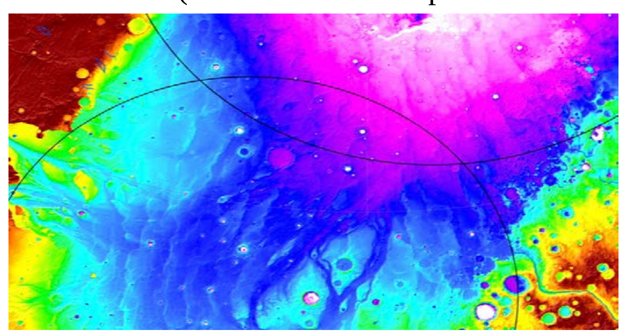
The Space Technology Roadmap Technology Area Breakdown Structure was used as a common taxonomy for assessing the intersections of the needs, competencies, commercialization and partnership priorities outlined above with the top 30 ["areas of significant overlap"]() (see Appendix A) highlighted as the areas of focus for the proposal call.

Each project is typically authorized between $100K and $250K full cost. Approved activities are required to provide a mid-term status report and a year-end report to the JTWG. For multi-year projects and at the discretion of the JTWG, up to two one-year extensions may be authorized. Multi-organizational participation is required and collaboration/cost-sharing with external partners is highly encouraged.

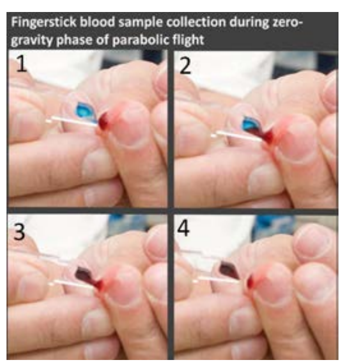
Directorate-Level Internal Research and Development

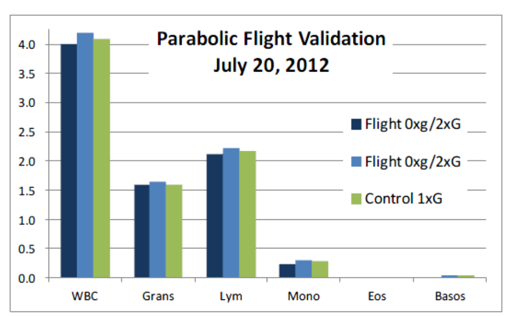
There is a concern that, in our efforts to encourage partnering and collaboration, certain Agency-unique competency areas that exist within a particular branch (or in some cases a particular *person*) will atrophy or wither away completely. The idea of a discretionary IR&D account managed by each of JSC's R&D producing directorates is intended to address this concern.

FY2011 Directorate IR&D accounts included resources for the Engineering, Astromaterials Research and Exploration Science, and Human Health and Performance Directorates and the White Sands Test Facility. For FY2012, the Directorate IR&D fund was expanded to include an allocation for Mission Operations and Safety and Mission Assurance Directorates. Project proposals for the Directorate-Level IR&D funding were requested in a similar manner as the Center



Mars – ancient floods and a possible ocean as seen in a 2012 JSC Directorate-Level IR&D Project supported by the CIF: GIS Technology – Resource and Habitability Assessment Tool by Carlton Allen and Dorothy Oehler





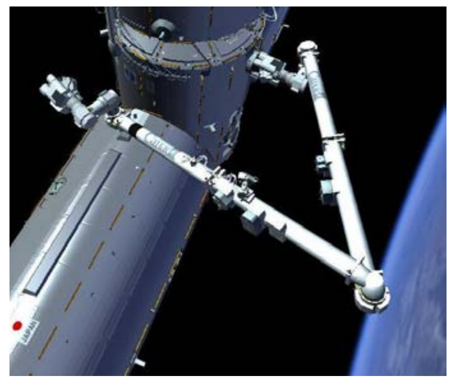
2012 JSC Directorate-Level IR&D Project supported by the CIF: Microgravity Cell Counter by Brian Crucian – (The fingerstick blood sample collection during gravity phase of parabolic flight and the flight validation chart)

IR&D projects with directorate management authorizing projects that address core technology competencies highlighted at the Center-level that are either uncovered or under-covered.

Each project is typically authorized up to between $10K and $100K full cost. Approved activities are required to provide a mid-term status report and a year-end report to the JTWG. For multi-year projects and at the discretion of the directorate management in coordination with the JTWG, up to two one-year extensions may be authorized. Though collaboration is encouraged, the Directorate IR&D fund does NOT include a partnering and multi-organizational participation requirement.

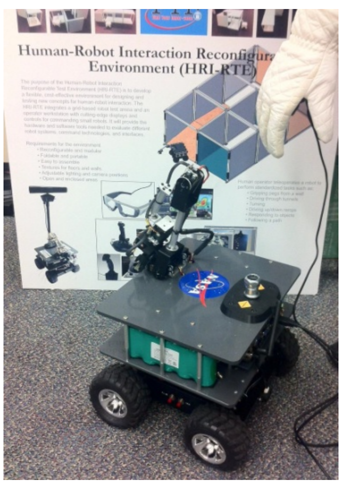
Innovation Charge Account

ICA is intended to address the need for "innovation time" recognized by the JSC Innovation and Inclusion Council. This effort also fosters a cross-Center environment of ingenuity and creativity at JSC by removing "filters" of oversight/control that sometimes inhibit promising ideas from being developed to determine initial merit.



A JSC 2012 ICA Project that received CIF support: Stitched Camera Array for Clearance Monitoring by Zach Drewry

Semi-annual "calls for ideas" are developed by the JSC CTO and then communicated to the JSC workforce via informal email distribution and JSC Today notices. A three member "panel of recognized innovators" reviews and prioritizes submitted ideas in a two-step process before submitting to the JSC Chief Technologist for approval. Part of the process involves a 60-second "elevator pitch" competition conducted at the JSC Collaboration Center in Building 3. The JSC workforce is invited to attend and learn about emerging ideas and cheer on their colleagues!



A JSC 2012 ICA Project that received CIF support: Gesture Commanding of a Robot While Wearing EVA Gloves by Neta Ezer, Ph.D.

ICA awards are numerous small dollar value awards, traditionally less than $10,000 full cost, and are given to allow individuals or small collaborative groups to pursue creative ideas. ICA studies typically last no more than four months and a short briefing to the JTWG is required at the end of the activity.

JSC CIF projects moving forward: Of the 50 JSC IR&D/ICA projects supported with the Center Innovations Fund, 21 have filed a New Technology Report through the JSC Tech Transfer Office. Several of these reports have received P1/T1 New Technology Evaluation ratings to pursue patents and additional ones have been scheduled for success story articles to be written and published.

A list of CIF-supported technology and innovation projects is included in Appendix B. Technical details for each of these projects are outlined in Appendix C. In all, over 50 CIF-funded project activities are included in this report.

Technology and Innovation Infrastructure

As NASA expands the horizons of human space exploration, its engineers and scientists must become increasingly creative in the solutions they design to meet ever more complex challenges. The JSC Chief Technologist works closely with other members of JSC senior staff to facilitate an environment of ingenuity and creative thinking.

Facilities and Creative Spaces

There are a number of facilities and creative spaces at JSC where the Center community can gather to develop ideas and plan. Creative spaces are free areas around the JSC Community and Sonny Carter Training Facility that have access to Wi-Fi and are open to anyone (no locked doors, no unnecessary layers of security). With the exception of the Building 3 Collaboration Center, these areas cannot be reserved, nor are they exclusive to any office, program or directorate. More than a dozen of these sites are located around JSC and are designed to be comfortable, fun, open places where people can work and meet away from their normal offices. The Building 3 Collaboration Area is one of the largest and was used to host the 2012 IR&D “Tech and Tell” poster sessions.

A JSC Creative Space – The Building 3 Collaboration Center before the 2012 IR&D “Tech and Tell” event

The Creative Café was introduced during Innovation Day 2012 as a venue for collaborative innovation. Activities in the café included rap forums on multiple issues, panel discussions with subject matter experts including astrophysicists, space architects and astronauts, and refreshments were available for patrons throughout the day. Hundreds of people enjoyed their first taste of the Creative Café and its offerings.

Welcoming Creative Café visitors

The design layout for the café includes a space art gallery at the entrance, bistro tables for short-term casual conversations, large round tables for more focused and in-depth discussions, a presentation stage and seating area for panel discussions and “rap forums”, as well as a concession area with coffee, tea, water, and light snacks all with a Parisian theme that included a hand-painted 50-foot backdrop. Due to the positive reviews received by the JSC Chief Technologist, the venue is being scheduled and reserved for additional use during other special events throughout the year.

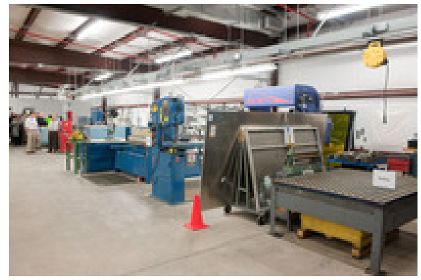
Creative Café patrons settle with refreshments and wait for a rap forum presentation to begin.

Rap session guest panelist takes questions from the Creative Café audience.

The Innovation Design Center (IDC) is another part of the innovation infrastructure at JSC. The Building 348 IDC is a 5,000 ft facility where the JSC workforce can meet and conduct hands-on innovative design, fabrication and testing of ideas that are relevant to NASA's mission.

The JSC IDC - Building 348

The IDC offers both a collaboration-meeting area and a basic fabrication shop. The meeting space features a CAD workstation, whiteboards, and wireless connectivity to assist in the discussion and maturation of ideas, designs and technologies. For concept development, a fabrication shop provides basic hand tools, as well as woodworking, machining, sheet metal, welding and electronics equipment, that can all be used for the hands-on development of project prototypes and working models. A new 3-D printer has also been installed and will be available for projects. Many CIF-funded IR&D and ICA investigations have been conducted in the IDC.



The IDC’s well-equipped machine shop allows engineers and researchers to design and construct prototypes and models to go along with their innovative ideas.

Fairs and Symposia

Several unique learning sessions and specialized forums are sponsored by the JSC CTO to encourage and support more innovation and creativity in the workplace.

Since 2010, Innovation Day has become one day that is set aside annually at JSC for employees to take time out of their regular work day to participate in an environment that fosters greater collaboration and creative thinking and exposes employees to ideas, issues and perspectives expressed by individuals outside of their normal circle of associates.

During Innovation 2012, there were plenty of opportunities and options for communicating and networking with innovative people throughout the Center. Throughout the day, guest speakers and “rap forum” discussions focused on a wide variety of topics revolving around innovation and new technologies. A free lunch was offered and numerous booths were set up around the Center to exhibit new technologies and innovations developed at JSC.

Directorate representatives and co-ops staffed booths with engaging activities where participants used creative thinking to solve design or puzzle problems. The activities are often challenging, informative, interesting and yes, fun!

Innovation 2012 participants came away with the understanding that innovation begins within and there is no “one way” to innovate. Every member of the JSC team was encouraged to bring personal passions to work; and be inspired to take chances and suggest new ideas.

Innovation Day 2012 exhibitors show off NASA developments and innovative ideas while participants enjoy learning new things and using creative thinking to solve puzzles and challenges including playing a life-size “*Angry Birds”* game.

All of the FY 2012 Center-Level and Directorate-Level IR&D projects, as well as all of the ICA award recipients support mid-term reviews with the JTWG and participate in an out-briefing type of event at the end of their activity. For the FY 2012 projects, two half-day IR&D “Tech & Tell” Poster Sessions were held in the JSC Collaboration Center.

Principal Investigators presented their work for review during the 2012 “Tech and Tell” Poster Session

Participants’ posters were displayed on easels and generally placed near other projects in a similar technical area. The principle investigators were able to showcase their projects with the poster and a number of presenters displayed prototypes for visitors and employees from across the Center. The CIF Program Executive and several industry representatives attended and were delighted to have the chance to visit with so many innovators in a single location at the same time.

A number of Principal Investigators brought prototypes with their posters to demonstrate their projects at the “Tech and Tell” event.

Workforce Initiatives
The JSC Chief Technologist is working with JSC’s Human Resources Development Office to pilot a number of creativity training courses including *Building, Leading, and Sustaining the Innovative Organization*, conducted by Professor Ralph Katz from the M.I.T. Sloan School of Management at M.I.T and *Enhancing Your Creative Genius*, a home-grown class developed at Langley Research Center and conducted by Karen Friedt. These and other pilot efforts are all purposeful ways to demonstrate or stimulate a culture of creativity across the Center.

JSC once again participated in and sponsored a prize at the annual Rice Business Plan Competition. The 5th annual NASA Awards coordination and judging helps the JSC Tech Transfer Office and the JSC Chief Technologist identify new partners for potential innovative collaborations. The participating entrepreneurs could help us cross over gaps or increase our competencies at the Center. The competition is intended to bring innovative entrepreneurial companies or individuals together so they can showcase developed business plans and solicit start-up funds from early stage investors and venture capital firms.

New for FY'13 -- As part of a major effort to push directorate cross-over collaboration and creative, innovative new technologies, several workforce initiatives have been created. A new series of "Tech Talks" are being organized to raise awareness among the JSC community surrounding the programs and developments happening at the Center. By bringing people together to hear from and interact with subject matter experts and primary investigators, new ideas should emerge and develop. More technology needs can be met when we broaden our knowledge base and encourage team work and joint efforts.

New for FY'13 -- Another part of the workforce initiatives the JSC CTO is developing for FY'13 is a new Cadre of Innovators. During FY12, the JSC Cadre of Innovators idea began to grow. The groundwork has been laid out for FY13 and we will induct several candidates for membership into an elite cadre, or core group of highly qualified personnel, who will be able to give back to the community by mentoring and guiding the younger talent at JSC. They also will share their experiences at public schools and universities to encourage young minds to consider careers in science, technology, engineering, and mathematics.

Communications

Communicating JSC technology R&D efforts, opportunities, and successes are of paramount importance. For this reason, the JSC CTO works to diversify the ways we disseminate information internally and externally. The Office's communication specialist produced news stories and features from technology related activities and works with the JSC Public Affairs Office (PAO) to provide news for press releases and any other NASA internal or external communication venues deemed appropriate.

In addition to promoting activities and sharing information through the JSC PAO, JSC Today email messages and Around JSC articles, the JSC CTO has developed the Technology@JSC (see Appendix D) website. The site allows for more new technology and innovation success stories and information to be published.

A screen capture of the Technology at JSC homepage

The site went live this summer and is continuing to develop. One of the outstanding tools available to users is the JSC Technology Calendar of Events (a summary events calendar for FY'13 is included in Appendix E). It is populated with local, Agency, and national technology related events, as well as training sessions, upcoming proposal call specifics, and details for R&D project reviews.

To help site visitors learn more about partnering opportunities with JSC, or technology licensing details, several links are provided to the JSC Partnering Opportunities area under Featured Links. Technology News is a column updated with news features and success stories related to technology research and development at the Center and the Agency. In addition, the Technology@JSC site includes a *Technologist's Toolbox* column that features an area where technologists can find information about creative spaces around JSC, answers to frequently asked questions concerning intellectual property, and even specifics on how to request a NASA intern.

The Technology@JSC website offers a link under Important Information for the JSC Technology Focus Area/Roadmaps as well as the Research and Development (R&D) Partnership Database. These helpful links, along with the Upcoming Opportunities section of the site connects site visitors to Agency, Center-level, Directorate and industry-related technology calls. The JSC Chief Technologist wants the Technology@JSC website to be a one-stop shopping place for those people interested in technology related stories, R&D information and opportunities for the JSC community and beyond.

Conclusion

JSC is fully committed to bringing the excitement and reward of innovation and technology to a growing community. The Center Innovation Fund support provides a tremendous resource that helps support the JSC Chief Technologist's Office continue the mission of encouraging a culture of creativity and innovation here at the Johnson Space Center. By inspiring new ideas, bringing excitement and the reward of innovation and technology to a growing R&D community, and focusing on the technology needs of the Agency, Johnson Space Center is continuing to show its commitment to being at the forefront of human space exploration.

Appendices

A. Technology "Areas of Significant Overlap" (Based on the Space Technology Area Breakdown Structure)
B. FY'12 Center Innovation Fund Supported Project Charts
C. JSC FY'12 CIF Support Project Details
D. Technology at JSC Homepage
E. The Year Ahead / Technology Calendar FY'13 One-Pager

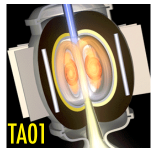
Appendix A

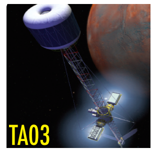
Technology "Areas of Significant Overlap"
(Based on the Space Technology Area Breakdown Structure)

AREAS OF SIGNIFICANT OVERLAP

National Aeronautics and Space Administration

OFFICIAL NASA ROADMAPS





TA01 • LAUNCH PROPULSION SYSTEMS

Solid Rocket Propulsion Systems
- Propellants
- Case Materials
- Nozzle Systems
- Hybrid Rocket Propulsion Systems
- Fundamental Solid Propulsion Technologies

Liquid Rocket Propulsion Systems
- LH_2/LOX Based
- RP/LOX Based
- CH_4/LOX Based
- Detonation Wave Engines (Closed Cycle)
- Propellants
- Fundamental Liquid Propulsion Technologies

Air Breathing Propulsion Systems
- TBCC
- RBCC
- Detonation Wave Engines (Open Cycle)
- Turbine Based Jet Engines (Flyback Boosters)
- Ramjet/Scramjet Engines (Accelerators)
- Deeply-cooled Air Cycles
- Air Collection & Enrichment System
- Fundamental Air Breathing Propulsion Technologies

Ancillary Propulsion Systems
- Auxiliary Control Systems
- Main Propulsion Systems (Excluding Engines)
- Launch Abort Systems
- Thrust Vector Control Systems
- Health Management & Sensors
- Pyro & Separation Systems
- Fundamental Ancillary Propulsion Technologies

Unconventional / Other Propulsion Systems
- Ground Launch Assist
- Air Launch / Drop Systems
- Space Tether Assist
- Beamed Energy / Energy Addition
- Nuclear
- High Energy Density Materials/Propellants

TA02 • IN-SPACE PROPULSION TECHNOLOGIES

Chemical Propulsion
- Liquid Storable
- Liquid Cryogenic
- Gels
- Solid
- Hybrid
- Cold Gas/Warm Gas
- Micro-propulsion

Non-Chemical Propulsion
- Electric Propulsion
- Solar Sail Propulsion
- Thermal Propulsion
- Tether Propulsion

Advanced (TRL <3) Propulsion Technologies
- Beamed Energy Propulsion
- Electric Sail Propulsion
- Fusion Propulsion
- High Energy Density Materials
- Antimatter Propulsion
- Advanced Fission
- Breakthrough Propulsion

Supporting Technologies
- Propellant Storage & Transfer

TA03 • SPACE POWER & ENERGY STORAGE

Power Generation
- Energy Harvesting
- Chemical (Fuel Cells, Heat Engines)
- Solar (Photo-Voltaic & Thermal)
- Radioisotope
- Fission
- Fusion

Energy Storage
- Batteries
- Flywheels
- Regenerative Fuel Cells

Power Management & Distribution
- FDIR
- Management & Control
- Distribution & Transmission
- Wireless Power Transmission
- Conversion & Regulation

Cross Cutting Technology
- Analytical Tools
- Green Energy Impact
- Multi-functional Structures
- Alternative Fuels

TA04 • ROBOTICS, TELE-ROBOTICS & AUTONOMOUS SYSTEMS

Sensing & Perception
- 3-D Perception
- Relative Position & Velocity Estimation
- Terrain Mapping, Classification & Characterization
- Natural & Man-made Object Recognition
- Sensor Fusion for Sampling & Manipulation
- Onboard Science Data Analysis

Mobility
- Extreme Terrain Mobility
- Below-Surface Mobility
- Above-Surface Mobility
- Small Body/Microgravity Mobility

Manipulation
- Robot Arms
- Dexterous Manipulators
- Modeling of Contact Dynamics
- Mobile Manipulation
- Collaborative Manipulation
- Robotic Drilling & Sample Processing

Human-Systems Integration
- Multi-Modal Human-Systems Interaction
- Supervisory Control
- Robot-to-Suit Interfaces
- Intent Recognition & Reaction
- Distributed Collaboration
- Common Human-Systems Interfaces
- Safety, Trust, & Interfacing of Robotic/Human Proximity Operations

Autonomy
- Vehicle Systems Management & FDIR
- Dynamic Planning & Sequencing Tools
- Autonomous Guidance & Control
- Multi-Agent Coordination
- Adjustable Autonomy
- Terrain Relative Navigation
- Path & Motion Planning with Uncertainty

Autonomous Rendezvous & Docking
- Relative Navigation Sensors (long-, mid-, near-range)
- Guidance Algorithms
- Docking & Capture Mechanisms/Interfaces
- Mission/System Managers for Autonomy/Automation

RTA Systems Engineering
- Modularity/Commonality
- Verification & Validation of Complex Adaptive Systems
- Onboard Computing

TA05 • COMMUNICATION & NAVIGATION

Optical Comm. & Navigation
- Detector Development
- Large Apertures
- Lasers
- Acquisition & Tracking
- Atmospheric Mitigation

Radio Frequency Communications
- Spectrum Efficient Technologies
- Power Efficient Technologies
- Propagation
- Flight & Ground Systems
- Earth Launch & Reentry Comm.
- Antennas

Internetworking
- Disruptive Tolerant Networking
- Adaptive Network Topology
- Information Assurance
- Integrated Network Management

Position, Navigation, and Timing
- Timekeeping & Time Distribution
- Onboard Auto Navigation & Maneuver
- Sensors & Vision Processing Systems
- Relative & Proximity Navigation
- Auto Precision Formation Flying
- Auto Approach & Landing

Integrated Technologies
- Radio Systems
- Ultra Wideband
- Cognitive Networks
- Science from the Comm. System
- Hybrid Optical Comm. & Navigation Sensors
- RF/Optical Hybrid Technology

Revolutionary Concepts
- X-Ray Navigation
- X-Ray Communications
- Neutrino-Based Nav. & Tracking
- Quantum Key Distribution
- Quantum Communications
- SQIF Microwave Amplifier
- Reconfigurable Large Apertures Using Nanosat Constellations

TA06 • HUMAN HEALTH, LIFE SUPPORT & HABITATION SYSTEMS

Environmental Control & Life Support Systems & Habitation Systems
- Air Revitalization
- Water Recovery & Management
- Waste Management
- Habitation

Extravehicular Activity Systems
- Pressure Garment
- Portable Life Support System
- Power, Avionics & Software

Human Health & Performance
- Medical Diagnosis / Prognosis
- Long-Duration Health
- Behavioral Health
- Human Factors

Environmental Monitoring, Safety & Emergency Response
- Sensors: Air, Water, Microbial, etc.
- Fire: Detection, Suppression, Recovery
- Protective Clothing / Breathing
- Remediation

Radiation
- Risk Assessment Modeling
- Radiation Mitigation
- Protection Systems
- Radiation prediction
- Monitoring Technology

TA07 • HUMAN EXPLORATION DESTINATION SYSTEMS

In-Situ Resource Utilization
- Destination Reconnaissance, Prospecting, & Mapping
- Resource Acquisition
- Consumables Production
- Manufacturing Products & Infrastructure Emplacement

Sustainability & Supportability
- Autonomous Logistics Management
- Maintenance Systems
- Repair Systems
- Food Production, Processing, & Preservation

"Advanced" Human Mobility Systems
- EVA Mobility
- Surface Mobility
- Off-Surface Mobility

"Advanced" Habitat Systems
- Integrated Habitat Systems
- Habitat Evolution
- "Smart" Habitats
- Artificial Gravity

Mission Operations & Safety
- Crew Training
- Planetary Safety
- Integrated Flight Operations Systems
- Integrated Risk Assessment Tools

Cross-Cutting Systems
- Construction & Assembly
- Particulate Contamination Prevention & Mitigation

TA08 • SCIENCE INSTRUMENTS, OBSERVATORIES & SENSOR SYSTEMS

Remote Sensing Instruments/Sensors
- Detectors & Focal Planes
- Electronics
- Optical Components
- Microwave / Radio
- Lasers
- Cryogenic / Thermal

Observatories
- Mirror Systems
- Structures & Antennas
- Distributed Aperture

In-Situ Instruments/Sensor
- Particles: Charged & Neutral
- Fields & Waves
- In-Situ

TA09 • ENTRY, DESCENT & LANDING SYSTEMS

Aeroassist & Atmospheric Entry
- Rigid Thermal Protection Systems
- Flexible Thermal Protection Systems
- Rigid Hypersonic Decelerators
- Deployable Hypersonic Decelerators

Descent
- Attached Deployable Decelerators
- Trailing Deployable Decelerators
- Supersonic Retropropulsion

Landing
- Touchdown Systems
- Egress & Deployment Systems
- Propulsion Systems
- Small Body Systems

Vehicle Systems Technology
- Separation Systems
- System Integration and Analyses
- Atmosphere & surface characterization
- Modeling and Simulation
- Instrumentation and Health Monitoring
- GN&C Sensors and Systems

TA10 • NANO-TECHNOLOGY

Engineered Materials & Structures
- Lightweight Structures
- Damage Tolerant Systems
- Coatings
- Adhesives
- Thermal Protection & Control

Energy Generation & Storage
- Energy Storage
- Energy Generation

Propulsion
- Propellants
- Propulsion Components
- In-Space Propulsion

Sensors, Electronics & Devices
- Sensors & Actuators
- Nanoelectronics
- Miniature Instruments

TA11 • MODELING, SIMULATION, INFORMATION TECHNOLOGY & PROCESSING

Computing
- Flight Computing
- Ground Computing

Modeling
- Software Modeling & Model-Checking
- Integrated Hardware & Software Modeling
- Human-System Performance Modeling
- Science Modeling
- Frameworks, Languages, Tools & Standards

Simulation
- Distributed Simulation
- Integrated System Lifecycle Simulation
- Simulation-Based Systems Engineering
- Simulation-Based Training & Decision Support Systems

Information Processing
- Science, Engineering & Mission Data Lifecycle
- Intelligent Data Understanding
- Semantic Technologies
- Collaborative Science & Engineering
- Advanced Mission Systems

TA12 • MATERIALS, STRUCTURES, MECHANICAL SYSTEMS & MANUFACTURING

Materials
- Lightweight Structure
- Computational Design
- Flexible Material Systems
- Environment
- Special Materials

Structures
- Lightweight Concepts
- Design & Certification Methods
- Reliability & Sustainment
- Test Tools & Methods
- Innovative, Multifunctional Concepts

Mechanical Systems
- Deployables, Docking and Interfaces
- Mechanism Life Extension Systems
- Electro-mechanical, Mechanical & Micromechanisms
- Design & Analysis Tools and Methods
- Reliability / Life Assessment / Health Monitoring
- Certification Methods

Manufacturing
- Manufacturing Processes
- Intelligent Integrated Manufacturing and Cyber Physical Systems
- Electronics & Optics Manufacturing Process
- Sustainable Manufacturing

Cross-Cutting
- Nondestructive Evaluation
- Model-Based Certification & Sustainment Methods
- Loads and Environments

TA13 • GROUND & LAUNCH SYSTEMS PROCESSING

Technologies to Optimize the Operational Life-Cycle
- Storage, Distribution & Conservation of Fluids
- Automated Alignment, Coupling, & Assembly Systems
- Autonomous Command & Control for Ground and Integrated Vehicle / Ground Systems

Environmental and Green Technologies
- Corrosion Prevention, Detection, & Mitigation
- Environmental Remediation & Site Restoration
- Preservation of Natural Eco-systems
- Alternate Energy Prototypes

Technologies to Increase Reliability and Mission Availability
- Advanced Launch Technologies
- Environment-Hardened Materials and Structures
- Inspection, Anomaly Detection & Identification
- Fault Isolation and Diagnostics
- Prognostics Technologies
- Repair, Mitigation, and Recovery Technologies
- Communications, Networking, Timing & Telemetry

Technologies to Improve Mission Safety/Mission Risk
- Range Tracking, Surveillance & Flight Safety Technologies
- Landing & Recovery Systems & Components
- Weather Prediction and Mitigation
- Robotics / Telerobotics
- Safety Systems

TA14 • THERMAL MANAGEMENT SYSTEMS

Cryogenic Systems
- Passive Thermal Control
- Active Thermal Control
- Integration & Modeling

Thermal Control Systems
- Heat Acquisition
- Heat Transfer
- Heat Rejection & Energy Storage

Thermal Protection Systems
- Entry / Ascent TPS
- Plume Shielding (Convective & Radiative)
- Sensor Systems & Measurement Technologies

JSC SUPPLEMENTAL DATA

TA15 • AERONAUTICS

Aerosciences
- Propulsion Airframe Integration
- Drag Reduction
- Novel Configurations
- Propulsion Airframe Aero-acoustics
- Computational Methods
- Robust Aero
- Formation Flight
- Wake Vortex
- VSTOL/ESTOL
- Reduce/Mitigate Sonic Boom
- Multidisciplinary Design & Analysis Tools
- Efficient Hypersonic Aero

Propulsion and Power
- Quiet Propulsion
- Ultraclean Propulsion & Alternative Fuels
- Fuel Efficiency
- Propulsion for STOL/VTOL
- Supersonic Propulsion
- Combined Cycle Hypersonic
- Aero-Propulsion-Servo-Elasticity
- Robust Propulsion
- Hybrid Propulsion and Power
- Variable Cycle
- Advanced Concepts/ Alternative Engine Cycles
- Intelligent Engine
- Integrated Power Management

Dynamics, Control, Navigation, Guidance, and Avionics
- Advanced Guidance
- Distributed Decision, Uncertainty, &Flight Path
- Distributed Flow Control of Vehicle Dynamics
- Intelligent & Adaptive Control
- Fault-Tolerant IVHM
- On-Board Weather
- Pilot Vehicle Integration
- Synthetic & Enhanced Vision
- UAV in the NAS
- Advanced V&V Techniques
- Load, Vibration & Stability Control
- Advanced Communications

Intelligent & Human Integrated Systems, Ops, Decision Making & Networking
- Complex Interactive Systems
- Separation Assurance
- Wake Vortex systems
- Architecture Vulnerability Analysis for Air Traffic Control
- Adaptive Air Traffic Control for Adverse Weather
- Collaborative Decision Systems
- Operational Maintenance Data
- Task & Attention Management
- Environmentally Friendly Aviation
- Super Density Operations

TA16 • ORBITAL DEBRIS AND HYPERVELOCITY IMPACT

Orbital Debris
- Modeling
- Monitoring
- Mitigation
- Remediation

Hypervelocity Impact
- Material Composition
- Experimental Investigations

TA17 • EMERGING TECHNOLOGIES

Space Technology Roadmaps **STR • TABS**

TECHNOLOGY AREA BREAKDOWN STRUCTURE

REVISED—08/17/12

HUMAN SPACE FLIGHT TECHNOLOGY NEEDS*

National Aeronautics and Space Administration

OFFICIAL NASA ROADMAPS

TA01 • LAUNCH PROPULSION SYSTEMS

Solid Rocket Propulsion Systems
- Propellants
- Case Materials
- Nozzle Systems
- Hybrid Rocket Propulsion Systems
- Fundamental Solid Propulsion Technologies

Liquid Rocket Propulsion Systems
- LH_2/LOX Based
- RP/LOX Based
- CH_4/LOX Based
- Detonation Wave Engines (Closed Cycle)
- Propellants
- Fundamental Liquid Propulsion Technologies

Air Breathing Propulsion Systems
- TBCC
- RBCC
- Detonation Wave Engines (Open Cycle)
- Turbine Based Jet Engines (Flyback Boosters)
- Ramjet/Scramjet Engines (Accelerators)
- Deeply-cooled Air Cycles
- Air Collection & Enrichment System
- Fundamental Air Breathing Propulsion Technologies

Ancillary Propulsion Systems
- Auxiliary Control Systems
- Main Propulsion Systems (Excluding Engines)
- Launch Abort Systems
- Thrust Vector Control Systems
- Health Management & Sensors
- Pyro & Separation Systems
- Fundamental Ancillary Propulsion Technologies

Unconventional / Other Propulsion Systems
- Ground Launch Assist
- Air Launch / Drop Systems
- Space Tether Assist
- Beamed Energy / Energy Addition
- Nuclear
- High Energy Density Materials/Propellants

TA02 • IN-SPACE PROPULSION TECHNOLOGIES

Chemical Propulsion
- Liquid Storable
- Liquid Cryogenic
- Gels
- Solid
- Hybrid
- Cold Gas/Warm Gas
- Micro-propulsion

Non-Chemical Propulsion
- Electric Propulsion
- Solar Sail Propulsion
- Thermal Propulsion
- Tether Propulsion

Advanced (TRL <3) Propulsion Technologies
- Beamed Energy Propulsion
- Electric Sail Propulsion
- Fusion Propulsion
- High Energy Density Materials
- Antimatter Propulsion
- Advanced Fission
- Breakthrough Propulsion

Supporting Technologies
- Propellant Storage & Transfer

TA03 • SPACE POWER & ENERGY STORAGE

Power Generation
- Energy Harvesting
- Chemical (Fuel Cells, Heat Engines)
- Solar (Photo-Voltaic & Thermal)
- Radioisotope
- Fission
- Fusion

Energy Storage
- Batteries
- Flywheels
- Regenerative Fuel Cells

Power Management & Distribution
- FDIR
- Management & Control
- Distribution & Transmission
- Wireless Power Transmission
- Conversion & Regulation

Cross Cutting Technology
- Analytical Tools
- Green Energy Impact
- Multi-functional Structures
- Alternative Fuels

TA04 • ROBOTICS, TELE-ROBOTICS & AUTONOMOUS SYSTEMS

Sensing & Perception
- 3-D Perception
- Relative Position & Velocity Estimation
- Terrain Mapping, Classification & Characterization
- Natural & Man-made Object Recognition
- Sensor Fusion for Sampling & Manipulation
- Onboard Science Data Analysis

Mobility
- Extreme Terrain Mobility
- Below-Surface Mobility
- Above-Surface Mobility
- Small Body/Microgravity Mobility

Manipulation
- Robot Arms
- Dexterous Manipulators
- Modeling of Contact Dynamics
- Mobile Manipulation
- Collaborative Manipulation
- Robotic Drilling & Sample Processing

Human-Systems Integration
- Multi-Modal Human-Systems Interaction
- Supervisory Control
- Robot-to-Suit Interfaces
- Intent Recognition & Reaction
- Distributed Collaboration
- Common Human-Systems Interfaces
- Safety, Trust, & Interfacing of Robotic/Human Proximity Operations

Autonomy
- Vehicle Systems Management & FDIR
- Dynamic Planning & Sequencing Tools
- Autonomous Guidance & Control
- Multi-Agent Coordination
- Adjustable Autonomy
- Terrain Relative Navigation
- Path & Motion Planning with Uncertainty

Autonomous Rendezvous & Docking
- Relative Navigation Sensors (long-, mid-, near-range)
- Guidance Algorithms
- Docking & Capture Mechanisms/Interfaces
- Mission/System Managers for Autonomy/Automation

RTA Systems Engineering
- Modularity/Commonality
- Verification & Validation of Complex Adaptive Systems
- Onboard Computing

TA05 • COMMUNICATION & NAVIGATION

Optical Comm. & Navigation
- Detector Development
- Large Apertures
- Lasers
- Acquisition & Tracking
- Atmospheric Mitigation

Radio Frequency Communications
- Spectrum Efficient Technologies
- Power Efficient Technologies
- Propagation
- Flight & Ground Systems
- Earth Launch & Reentry Comm.
- Antennas

Internetworking
- Disruptive Tolerant Networking
- Adaptive Network Topology
- Information Assurance
- Integrated Network Management

Position, Navigation, and Timing
- Timekeeping & Time Distribution
- Onboard Auto Navigation & Maneuver
- Sensors & Vision Processing Systems
- Relative & Proximity Navigation
- Auto Precision Formation Flying
- Auto Approach & Landing

Integrated Technologies
- Radio Systems
- Ultra Wideband
- Cognitive Networks
- Science from the Comm. System
- Hybrid Optical Comm. & Navigation Sensors
- RF/Optical Hybrid Technology

Revolutionary Concepts
- X-Ray Navigation
- X-Ray Communications
- Neutrino-Based Nav. & Tracking
- Quantum Key Distribution
- Quantum Communications
- SQIF Microwave Amplifier
- Reconfigurable Large Apertures Using Nanosat Constellations

TA06 • HUMAN HEALTH, LIFE SUPPORT & HABITATION SYSTEMS

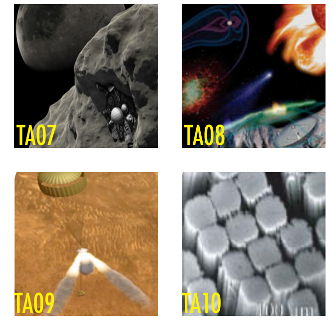
Environmental Control & Life Support Systems & Habitation Systems
- Air Revitalization
- Water Recovery & Management
- Waste Management
- Habitation

Extravehicular Activity Systems
- Pressure Garment
- Portable Life Support System
- Power, Avionics & Software

Human Health & Performance
- Medical Diagnosis / Prognosis
- Long-Duration Health
- Behavioral Health
- Human Factors

Environmental Monitoring, Safety & Emergency Response
- Sensors: Air, Water, Microbial, etc.
- Fire: Detection, Suppression, Recovery
- Protective Clothing / Breathing
- Remediation

Radiation
- Risk Assessment Modeling
- Radiation Mitigation
- Protection Systems
- Radiation prediction
- Monitoring Technology



TA07 • HUMAN EXPLORATION DESTINATION SYSTEMS

In-Situ Resource Utilization
- Destination Reconnaissance, Prospecting, & Mapping
- Resource Acquisition
- Consumables Production
- Manufacturing Products & Infrastructure Emplacement

Sustainability & Supportability
- Autonomous Logistics Management
- Maintenance Systems
- Repair Systems
- Food Production, Processing, & Preservation

"Advanced" Human Mobility Systems
- EVA Mobility
- Surface Mobility
- Off-Surface Mobility

"Advanced" Habitat Systems
- Integrated Habitat Systems
- Habitat Evolution
- "Smart" Habitats
- Artificial Gravity

Mission Operations & Safety
- Crew Training
- Planetary Safety
- Integrated Flight Operations Systems
- Integrated Risk Assessment Tools

Cross-Cutting Systems
- Construction & Assembly
- Particulate Contamination Prevention & Mitigation

TA08 • SCIENCE INSTRUMENTS, OBSERVATORIES & SENSOR SYSTEMS

Remote Sensing Instruments/Sensors
- Detectors & Focal Planes
- Electronics
- Optical Components
- Microwave / Radio
- Lasers
- Cryogenic / Thermal

Observatories
- Mirror Systems
- Structures & Antennas
- Distributed Aperture

In-Situ Instruments/Sensor
- Particles: Charged & Neutral
- Fields & Waves
- In-Situ

TA09 • ENTRY, DESCENT & LANDING SYSTEMS

Aeroassist & Atmospheric Entry
- Rigid Thermal Protection Systems
- Flexible Thermal Protection Systems
- Rigid Hypersonic Decelerators
- Deployable Hypersonic Decelerators

Descent
- Attached Deployable Decelerators
- Trailing Deployable Decelerators
- Supersonic Retropropulsion

Landing
- Touchdown Systems
- Egress & Deployment Systems
- Propulsion Systems
- Small Body Systems

Vehicle Systems Technology
- Separation Systems
- System Integration and Analyses
- Atmosphere & surface characterization
- Modeling and Simulation
- Instrumentation and Health Monitoring
- GN&C Sensors and Systems

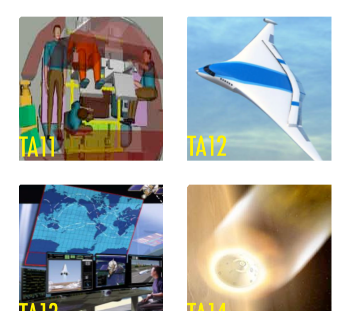
TA10 • NANO-TECHNOLOGY

Engineered Materials & Structures
- Lightweight Structures
- Damage Tolerant Systems
- Coatings
- Adhesives
- Thermal Protection & Control

Energy Generation & Storage
- Energy Storage
- Energy Generation

Propulsion
- Propellants
- Propulsion Components
- In-Space Propulsion

Sensors, Electronics & Devices
- Sensors & Actuators
- Nanoelectronics
- Miniature Instruments



TA11 • MODELING, SIMULATION, INFORMATION TECHNOLOGY & PROCESSING

Computing
- Flight Computing
- Ground Computing

Modeling
- Software Modeling & Model-Checking
- Integrated Hardware & Software Modeling
- Human-System Performance Modeling
- Science Modeling
- Frameworks, Languages, Tools & Standards

Simulation
- Distributed Simulation
- Integrated System Lifecycle Simulation
- Simulation-Based Systems Engineering
- Simulation-Based Training & Decision Support Systems

Information Processing
- Science, Engineering & Mission Data Lifecycle
- Intelligent Data Understanding
- Semantic Technologies
- Collaborative Science & Engineering
- Advanced Mission Systems

TA12 • MATERIALS, STRUCTURES, MECHANICAL SYSTEMS & MANUFACTURING

Materials
- Lightweight Structure
- Computational Design
- Flexible Material Systems
- Environment
- Special Materials

Structures
- Lightweight Concepts
- Design & Certification Methods
- Reliability & Sustainment
- Test Tools & Methods
- Innovative, Multifunctional Concepts

Mechanical Systems
- Deployables, Docking and Interfaces
- Mechanism Life Extension Systems
- Electro-mechanical, Mechanical & Micromechanisms
- Design & Analysis Tools and Methods
- Reliability / Life Assessment / Health Monitoring
- Certification Methods

Manufacturing
- Manufacturing Processes
- Intelligent Integrated Manufacturing and Cyber Physical Systems
- Electronics & Optics Manufacturing Process
- Sustainable Manufacturing

Cross-Cutting
- Nondestructive Evaluation
- Model-Based Certification & Sustainment Methods
- Loads and Environments

TA13 • GROUND & LAUNCH SYSTEMS PROCESSING

Technologies to Optimize the Operational Life-Cycle
- Storage, Distribution & Conservation of Fluids
- Automated Alignment, Coupling, & Assembly Systems
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Environmental and Green Technologies
- Corrosion Prevention, Detection, & Mitigation
- Environmental Remediation & Site Restoration
- Preservation of Natural Eco-systems
- Alternate Energy Prototypes

Technologies to Increase Reliability and Mission Availability
- Advanced Launch Technologies
- Environment-Hardened Materials and Structures
- Inspection, Anomaly Detection & Identification
- Fault Isolation and Diagnostics
- Prognostics Technologies
- Repair, Mitigation, and Recovery Technologies
- Communications, Networking, Timing & Telemetry

Technologies to Improve Mission Safety/Mission Risk
- Range Tracking, Surveillance & Flight Safety Technologies
- Landing & Recovery Systems & Components
- Weather Prediction and Mitigation
- Robotics / Telerobotics
- Safety Systems

TA14 • THERMAL MANAGEMENT SYSTEMS

Cryogenic Systems
- Passive Thermal Control
- Active Thermal Control
- Integration & Modeling

Thermal Control Systems
- Heat Acquisition
- Heat Transfer
- Heat Rejection & Energy Storage

Thermal Protection Systems
- Entry / Ascent TPS
- Plume Shielding (Convective & Radiative)
- Sensor Systems & Measurement Technologies

JSC SUPPLEMENTAL DATA

TA15 • AERONAUTICS

Aerosciences
- Propulsion Airframe Integration
- Drag Reduction
- Novel Configurations
- Propulsion Airframe Aero-acoustics
- Computational Methods
- Robust Aero
- Formation Flight
- Wake Vortex
- VSTOL/ESTOL
- Reduce/Mitigate Sonic Boom
- Multidisciplinary Design & Analysis Tools
- Efficient Hypersonic Aero

Propulsion and Power
- Quiet Propulsion
- Ultraclean Propulsion & Alternative Fuels
- Fuel Efficiency
- Propulsion for STOL/VTOL
- Supersonic Propulsion
- Combined Cycle Hypersonic
- Aero-Propulsion-Servo-Elasticity
- Robust Propulsion
- Hybrid Propulsion and Power
- Variable Cycle
- Advanced Concepts/ Alternative Engine Cycles
- Intelligent Engine
- Integrated Power Management

Dynamics, Control, Navigation, Guidance, and Avionics
- Advanced Guidance
- Distributed Decision, Uncertainty, &Flight Path
- Distributed Flow Control of Vehicle Dynamics
- Intelligent & Adaptive Control
- Fault-Tolerant IVHM
- On-Board Weather
- Pilot Vehicle Integration
- Synthetic & Enhanced Vision
- UAV in the NAS
- Advanced V&V Techniques
- Load, Vibration & Stability Control
- Advanced Communications

Intelligent & Human Integrated Systems, Ops, Decision Making & Networking
- Complex Interactive Systems
- Separation Assurance
- Wake Vortex systems
- Architecture Vulnerability Analysis for Air Traffic Control
- Adaptive Air Traffic Control for Adverse Weather
- Collaborative Decision Systems
- Operational Maintenance Data
- Task & Attention Management
- Environmentally Friendly Aviation
- Super Density Operations

TA16 • ORBITAL DEBRIS AND HYPERVELOCITY IMPACT

Orbital Debris
- Modeling
- Monitoring
- Mitigation
- Remediation

Hypervelocity Impact
- Material Composition
- Experimental Investigations

TA17 • EMERGING TECHNOLOGIES

Space Technology Roadmaps **STR • TABS**

TECHNOLOGY AREA BREAKDOWN STRUCTURE

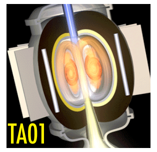
REVISED—08/10/12

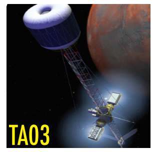
* *Can include HAT, HRP, ISS, Orion, SMD, etc. technology needs in support of future NASA missions.*

JSC CORE TECHNOLOGY COMPETENCIES

National Aeronautics and Space Administration

OFFICIAL NASA ROADMAPS





TA01 • LAUNCH PROPULSION SYSTEMS

Solid Rocket Propulsion Systems
- Propellants
- Case Materials
- Nozzle Systems
- Hybrid Rocket Propulsion Systems
- Fundamental Solid Propulsion Technologies

Liquid Rocket Propulsion Systems
- LH_2/LOX Based
- RP/LOX Based
- CH_4/LOX Based
- Detonation Wave Engines (Closed Cycle)
- Propellants
- Fundamental Liquid Propulsion Technologies

Air Breathing Propulsion Systems
- TBCC
- RBCC
- Detonation Wave Engines (Open Cycle)
- Turbine Based Jet Engines (Flyback Boosters)
- Ramjet/Scramjet Engines (Accelerators)
- Deeply-cooled Air Cycles
- Air Collection & Enrichment System
- Fundamental Air Breathing Propulsion Technologies

Ancillary Propulsion Systems
- Auxiliary Control Systems
- Main Propulsion Systems (Excluding Engines)
- Launch Abort Systems
- Thrust Vector Control Systems
- Health Management & Sensors
- Pyro & Separation Systems
- Fundamental Ancillary Propulsion Technologies

Unconventional / Other Propulsion Systems
- Ground Launch Assist
- Air Launch / Drop Systems
- Space Tether Assist
- Beamed Energy / Energy Addition
- Nuclear
- High Energy Density Materials/Propellants

TA02 • IN-SPACE PROPULSION TECHNOLOGIES

Chemical Propulsion
- Liquid Storable
- Liquid Cryogenic
- Gels
- Solid
- Hybrid
- Cold Gas/Warm Gas
- Micro-propulsion

Non-Chemical Propulsion
- Electric Propulsion
- Solar Sail Propulsion
- Thermal Propulsion
- Tether Propulsion

Advanced (TRL <3) Propulsion Technologies
- Beamed Energy Propulsion
- Electric Sail Propulsion
- Fusion Propulsion
- High Energy Density Materials
- Antimatter Propulsion
- Advanced Fission
- Breakthrough Propulsion

Supporting Technologies
- Propellant Storage & Transfer

TA03 • SPACE POWER & ENERGY STORAGE

Power Generation
- Energy Harvesting
- Chemical (Fuel Cells, Heat Engines)
- Solar (Photo-Voltaic & Thermal)
- Radioisotope
- Fission
- Fusion

Energy Storage
- Batteries
- Flywheels
- Regenerative Fuel Cells

Power Management & Distribution
- FDIR
- Management & Control
- Distribution & Transmission
- Wireless Power Transmission
- Conversion & Regulation

Cross Cutting Technology
- Analytical Tools
- Green Energy Impact
- Multi-functional Structures
- Alternative Fuels

TA04 • ROBOTICS, TELE-ROBOTICS & AUTONOMOUS SYSTEMS

Sensing & Perception
- 3-D Perception
- Relative Position & Velocity Estimation
- Terrain Mapping, Classification & Characterization
- Natural & Man-made Object Recognition
- Sensor Fusion for Sampling & Manipulation
- Onboard Science Data Analysis

Mobility
- Extreme Terrain Mobility
- Below-Surface Mobility
- Above-Surface Mobility
- Small Body/Microgravity Mobility

Manipulation
- Robot Arms
- Dexterous Manipulators
- Modeling of Contact Dynamics
- Mobile Manipulation
- Collaborative Manipulation
- Robotic Drilling & Sample Processing

Human-Systems Integration
- Multi-Modal Human-Systems Interaction
- Supervisory Control
- Robot-to-Suit Interfaces
- Intent Recognition & Reaction
- Distributed Collaboration
- Common Human-Systems Interfaces
- Safety, Trust, & Interfacing of Robotic/Human Proximity Operations

Autonomy
- Vehicle Systems Management & FDIR
- Dynamic Planning & Sequencing Tools
- Autonomous Guidance & Control
- Multi-Agent Coordination
- Adjustable Autonomy
- Terrain Relative Navigation
- Path & Motion Planning with Uncertainty

Autonomous Rendezvous & Docking
- Relative Navigation Sensors (long-, mid-, near-range)
- Guidance Algorithms
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RTA Systems Engineering
- Modularity/Commonality
- Verification & Validation of Complex Adaptive Systems
- Onboard Computing

TA05 • COMMUNICATION & NAVIGATION

Optical Comm. & Navigation
- Detector Development
- Large Apertures
- Lasers
- Acquisition & Tracking
- Atmospheric Mitigation

Radio Frequency Communications
- Spectrum Efficient Technologies
- Power Efficient Technologies
- Propagation
- Flight & Ground Systems
- Earth Launch & Reentry Comm.
- Antennas

Internetworking
- Disruptive Tolerant Networking
- Adaptive Network Topology
- Information Assurance
- Integrated Network Management

Position, Navigation, and Timing
- Timekeeping & Time Distribution
- Onboard Auto Navigation & Maneuver
- Sensors & Vision Processing Systems
- Relative & Proximity Navigation
- Auto Precision Formation Flying
- Auto Approach & Landing

Integrated Technologies
- Radio Systems
- Ultra Wideband
- Cognitive Networks
- Science from the Comm. System
- Hybrid Optical Comm. & Navigation Sensors
- RF/Optical Hybrid Technology

Revolutionary Concepts
- X-Ray Navigation
- X-Ray Communications
- Neutrino-Based Nav. & Tracking
- Quantum Key Distribution
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- SQIF Microwave Amplifier
- Reconfigurable Large Apertures Using Nanosat Constellations

TA06 • HUMAN HEALTH, LIFE SUPPORT & HABITATION SYSTEMS

Environmental Control & Life Support Systems & Habitation Systems
- Air Revitalization
- Water Recovery & Management
- Waste Management
- Habitation

Extravehicular Activity Systems
- Pressure Garment
- Portable Life Support System
- Power, Avionics & Software

Human Health & Performance
- Medical Diagnosis / Prognosis
- Long-Duration Health
- Behavioral Health
- Human Factors

Environmental Monitoring, Safety & Emergency Response
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- Fire: Detection, Suppression, Recovery
- Protective Clothing / Breathing
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Radiation
- Risk Assessment Modeling
- Radiation Mitigation
- Protection Systems
- Radiation prediction
- Monitoring Technology

TA07 • HUMAN EXPLORATION DESTINATION SYSTEMS

In-Situ Resource Utilization
- Destination Reconnaissance, Prospecting, & Mapping
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- Consumables Production
- Manufacturing Products & Infrastructure Emplacement

Sustainability & Supportability
- Autonomous Logistics Management
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"Advanced" Human Mobility Systems
- EVA Mobility
- Surface Mobility
- Off-Surface Mobility

"Advanced" Habitat Systems
- Integrated Habitat Systems
- Habitat Evolution
- "Smart" Habitats
- Artificial Gravity

Mission Operations & Safety
- Crew Training
- Planetary Safety
- Integrated Flight Operations Systems
- Integrated Risk Assessment Tools

Cross-Cutting Systems
- Construction & Assembly
- Particulate Contamination Prevention & Mitigation

TA08 • SCIENCE INSTRUMENTS, OBSERVATORIES & SENSOR SYSTEMS

Remote Sensing Instruments/Sensors
- Detectors & Focal Planes
- Electronics
- Optical Components
- Microwave / Radio
- Lasers
- Cryogenic / Thermal

Observatories
- Mirror Systems
- Structures & Antennas
- Distributed Aperture

In-Situ Instruments/Sensor
- Particles: Charged & Neutral
- Fields & Waves
- In-Situ

TA09 • ENTRY, DESCENT & LANDING SYSTEMS

Aeroassist & Atmospheric Entry
- Rigid Thermal Protection Systems
- Flexible Thermal Protection Systems
- Rigid Hypersonic Decelerators
- Deployable Hypersonic Decelerators

Descent
- Attached Deployable Decelerators
- Trailing Deployable Decelerators
- Supersonic Retropropulsion

Landing
- Touchdown Systems
- Egress & Deployment Systems
- Propulsion Systems
- Small Body Systems

Vehicle Systems Technology
- Separation Systems
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- Instrumentation and Health Monitoring
- GN&C Sensors and Systems

TA10 • NANO-TECHNOLOGY

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- Advanced Mission Systems

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- Flexible Material Systems
- Environment
- Special Materials

Structures
- Lightweight Concepts
- Design & Certification Methods
- Reliability & Sustainment
- Test Tools & Methods
- Innovative, Multifunctional Concepts

Mechanical Systems
- Deployables, Docking and Interfaces
- Mechanism Life Extension Systems
- Electro-mechanical, Mechanical & Micromechanisms
- Design & Analysis Tools and Methods
- Reliability / Life Assessment / Health Monitoring
- Certification Methods

Manufacturing
- Manufacturing Processes
- Intelligent Integrated Manufacturing and Cyber Physical Systems
- Electronics & Optics Manufacturing Process
- Sustainable Manufacturing

Cross-Cutting
- Nondestructive Evaluation
- Model-Based Certification & Sustainment Methods
- Loads and Environments

TA13 • GROUND & LAUNCH SYSTEMS PROCESSING

Technologies to Optimize the Operational Life-Cycle
- Storage, Distribution & Conservation of Fluids
- Automated Alignment, Coupling, & Assembly Systems
- Autonomous Command & Control for Ground and Integrated Vehicle / Ground Systems

Environmental and Green Technologies
- Corrosion Prevention, Detection, & Mitigation
- Environmental Remediation & Site Restoration
- Preservation of Natural Eco-systems
- Alternate Energy Prototypes

Technologies to Increase Reliability and Mission Availability
- Advanced Launch Technologies
- Environment-Hardened Materials and Structures
- Inspection, Anomaly Detection & Identification
- Fault Isolation and Diagnostics
- Prognostics Technologies
- Repair, Mitigation, and Recovery Technologies
- Communications, Networking, Timing & Telemetry

Technologies to Improve Mission Safety/Mission Risk
- Range Tracking, Surveillance & Flight Safety Technologies
- Landing & Recovery Systems & Components
- Weather Prediction and Mitigation
- Robotics / Telerobotics
- Safety Systems

TA14 • THERMAL MANAGEMENT SYSTEMS

Cryogenic Systems
- Passive Thermal Control
- Active Thermal Control
- Integration & Modeling

Thermal Control Systems
- Heat Acquisition
- Heat Transfer
- Heat Rejection & Energy Storage

Thermal Protection Systems
- Entry / Ascent TPS
- Plume Shielding (Convective & Radiative)
- Sensor Systems & Measurement Technologies

JSC SUPPLEMENTAL DATA

TA15 • AERONAUTICS

Aerosciences
- Propulsion Airframe Integration
- Drag Reduction
- Novel Configurations
- Propulsion Airframe Aero-acoustics
- Computational Methods
- Robust Aero
- Formation Flight
- Wake Vortex
- VSTOL/ESTOL
- Reduce/Mitigate Sonic Boom
- Multidisciplinary Design & Analysis Tools
- Efficient Hypersonic Aero

Propulsion and Power
- Quiet Propulsion
- Ultraclean Propulsion & Alternative Fuels
- Fuel Efficiency
- Propulsion for STOL/VTOL
- Supersonic Propulsion
- Combined Cycle Hypersonic
- Aero-Propulsion-Servo-Elasticity
- Robust Propulsion
- Hybrid Propulsion and Power
- Variable Cycle
- Advanced Concepts/ Alternative Engine Cycles
- Intelligent Engine
- Integrated Power Management

Dynamics, Control, Navigation, Guidance, and Avionics
- Advanced Guidance
- Distributed Decision, Uncertainty, &Flight Path
- Distributed Flow Control of Vehicle Dynamics
- Intelligent & Adaptive Control
- Fault-Tolerant IVHM
- On-Board Weather
- Pilot Vehicle Integration
- Synthetic & Enhanced Vision
- UAV in the NAS
- Advanced V&V Techniques
- Load, Vibration & Stability Control
- Advanced Communications

Intelligent & Human Integrated Systems, Ops, Decision Making & Networking
- Complex Interactive Systems
- Separation Assurance
- Wake Vortex systems
- Architecture Vulnerability Analysis for Air Traffic Control
- Adaptive Air Traffic Control for Adverse Weather
- Collaborative Decision Systems
- Operational Maintenance Data
- Task & Attention Management
- Environmentally Friendly Aviation
- Super Density Operations

TA16 • ORBITAL DEBRIS AND HYPERVELOCITY IMPACT

Orbital Debris
- Modeling
- Monitoring
- Mitigation
- Remediation

Hypervelocity Impact
- Material Composition
- Experimental Investigations

TA17 • EMERGING TECHNOLOGIES

Space Technology Roadmaps STR • TABS

TECHNOLOGY AREA BREAKDOWN STRUCTURE

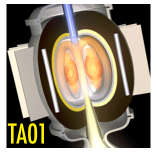
REVISED—08/10/12

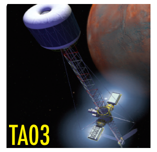
Note: Only JSC core competencies are highlighted.

COMMERCIALIZATION POTENTIAL – JSC PERSPECTIVE

National Aeronautics and Space Administration

OFFICIAL NASA ROADMAPS





TA01 • LAUNCH PROPULSION SYSTEMS

Solid Rocket Propulsion Systems
- Propellants
- Case Materials
- Nozzle Systems
- Hybrid Rocket Propulsion Systems
- Fundamental Solid Propulsion Technologies

Liquid Rocket Propulsion Systems
- LH$_2$/LOX Based
- RP/LOX Based
- CH$_4$/LOX Based
- Detonation Wave Engines (Closed Cycle)
- Propellants
- Fundamental Liquid Propulsion Technologies

Air Breathing Propulsion Systems
- TBCC
- RBCC
- Detonation Wave Engines (Open Cycle)
- Turbine Based Jet Engines (Flyback Boosters)
- Ramjet/Scramjet Engines (Accelerators)
- Deeply-cooled Air Cycles
- Air Collection & Enrichment System
- Fundamental Air Breathing Propulsion Technologies

Ancillary Propulsion Systems
- Auxiliary Control Systems
- Main Propulsion Systems (Excluding Engines)
- Launch Abort Systems
- Thrust Vector Control Systems
- Health Management & Sensors
- Pyro & Separation Systems
- Fundamental Ancillary Propulsion Technologies

Unconventional / Other Propulsion Systems
- Ground Launch Assist
- Air Launch / Drop Systems
- Space Tether Assist
- Beamed Energy / Energy Addition
- Nuclear
- High Energy Density Materials/Propellants

TA02 • IN-SPACE PROPULSION TECHNOLOGIES

Chemical Propulsion
- Liquid Storable
- Liquid Cryogenic
- Gels
- Solid
- Hybrid
- Cold Gas/Warm Gas
- Micro-propulsion

Non-Chemical Propulsion
- Electric Propulsion
- Solar Sail Propulsion
- Thermal Propulsion
- Tether Propulsion

Advanced (TRL <3) Propulsion Technologies
- Beamed Energy Propulsion
- Electric Sail Propulsion
- Fusion Propulsion
- High Energy Density Materials
- Antimatter Propulsion
- Advanced Fission
- Breakthrough Propulsion

Supporting Technologies
- Propellant Storage & Transfer

TA03 • SPACE POWER & ENERGY STORAGE

Power Generation
- Energy Harvesting
- Chemical (Fuel Cells, Heat Engines)
- Solar (Photo-Voltaic & Thermal)
- Radioisotope
- Fission
- Fusion

Energy Storage
- Batteries
- Flywheels
- Regenerative Fuel Cells

Power Management & Distribution
- FDIR
- Management & Control
- Distribution & Transmission
- Wireless Power Transmission
- Conversion & Regulation

Cross Cutting Technology
- Analytical Tools
- Green Energy Impact
- Multi-functional Structures
- Alternative Fuels

TA04 • ROBOTICS, TELE-ROBOTICS & AUTONOMOUS SYSTEMS

Sensing & Perception
- 3-D Perception
- Relative Position & Velocity Estimation
- Terrain Mapping, Classification & Characterization
- Natural & Man-made Object Recognition
- Sensor Fusion for Sampling & Manipulation
- Onboard Science Data Analysis

Mobility
- Extreme Terrain Mobility
- Below-Surface Mobility
- Above-Surface Mobility
- Small Body/Microgravity Mobility

Manipulation
- Robot Arms
- Dexterous Manipulators
- Modeling of Contact Dynamics
- Mobile Manipulation
- Collaborative Manipulation
- Robotic Drilling & Sample Processing

Human-Systems Integration
- Multi-Modal Human-Systems Interaction
- Supervisory Control
- Robot-to-Suit Interfaces
- Intent Recognition & Reaction
- Distributed Collaboration
- Common Human-Systems Interfaces
- Safety, Trust, & Interfacing of Robotic/Human Proximity Operations

Autonomy
- Vehicle Systems Management & FDIR
- Dynamic Planning & Sequencing Tools
- Autonomous Guidance & Control
- Multi-Agent Coordination
- Adjustable Autonomy
- Terrain Relative Navigation
- Path & Motion Planning with Uncertainty

Autonomous Rendezvous & Docking
- Relative Navigation Sensors (long-, mid-, near-range)
- Guidance Algorithms
- Docking & Capture Mechanisms/Interfaces
- Mission/System Managers for Autonomy/Automation

RTA Systems Engineering
- Modularity/Commonality
- Verification & Validation of Complex Adaptive Systems
- Onboard Computing

TA05 • COMMUNICATION & NAVIGATION

Optical Comm. & Navigation
- Detector Development
- Large Apertures
- Lasers
- Acquisition & Tracking
- Atmospheric Mitigation

Radio Frequency Communications
- Spectrum Efficient Technologies
- Power Efficient Technologies
- Propagation
- Flight & Ground Systems
- Earth Launch & Reentry Comm.
- Antennas

Internetworking
- Disruptive Tolerant Networking
- Adaptive Network Topology
- Information Assurance
- Integrated Network Management

Position, Navigation, and Timing
- Timekeeping & Time Distribution
- Onboard Auto Navigation & Maneuver
- Sensors & Vision Processing Systems
- Relative & Proximity Navigation
- Auto Precision Formation Flying
- Auto Approach & Landing

Integrated Technologies
- Radio Systems
- Ultra Wideband
- Cognitive Networks
- Science from the Comm. System
- Hybrid Optical Comm. & Navigation Sensors
- RF/Optical Hybrid Technology

Revolutionary Concepts
- X-Ray Navigation
- X-Ray Communications
- Neutrino-Based Nav. & Tracking
- Quantum Key Distribution
- Quantum Communications
- SQIF Microwave Amplifier
- Reconfigurable Large Apertures Using Nanosat Constellations

TA06 • HUMAN HEALTH, LIFE SUPPORT & HABITATION SYSTEMS

Environmental Control & Life Support Systems & Habitation Systems
- Air Revitalization
- Water Recovery & Management
- Waste Management
- Habitation

Extravehicular Activity Systems
- Pressure Garment
- Portable Life Support System
- Power, Avionics & Software

Human Health & Performance
- Medical Diagnosis / Prognosis
- Long-Duration Health
- Behavioral Health
- Human Factors

Environmental Monitoring, Safety & Emergency Response
- Sensors: Air, Water, Microbial, etc.
- Fire: Detection, Suppression, Recovery
- Protective Clothing / Breathing
- Remediation

Radiation
- Risk Assessment Modeling
- Radiation Mitigation
- Protection Systems
- Radiation prediction
- Monitoring Technology

TA07 • HUMAN EXPLORATION DESTINATION SYSTEMS

In-Situ Resource Utilization
- Destination Reconnaissance, Prospecting, & Mapping
- Resource Acquisition
- Consumables Production
- Manufacturing Products & Infrastructure Emplacement

Sustainability & Supportability
- Autonomous Logistics Management
- Maintenance Systems
- Repair Systems
- Food Production, Processing, & Preservation

"Advanced" Human Mobility Systems
- EVA Mobility
- Surface Mobility
- Off-Surface Mobility

"Advanced" Habitat Systems
- Integrated Habitat Systems
- Habitat Evolution
- "Smart" Habitats
- Artificial Gravity

Mission Operations & Safety
- Crew Training
- Planetary Safety
- Integrated Flight Operations Systems
- Integrated Risk Assessment Tools

Cross-Cutting Systems
- Construction & Assembly
- Particulate Contamination Prevention & Mitigation

TA08 • SCIENCE INSTRUMENTS, OBSERVATORIES & SENSOR SYSTEMS

Remote Sensing Instruments/Sensors
- Detectors & Focal Planes
- Electronics
- Optical Components
- Microwave / Radio
- Lasers
- Cryogenic / Thermal

Observatories
- Mirror Systems
- Structures & Antennas
- Distributed Aperture

In-Situ Instruments/Sensor
- Particles: Charged & Neutral
- Fields & Waves
- In-Situ

TA09 • ENTRY, DESCENT & LANDING SYSTEMS

Aeroassist & Atmospheric Entry
- Rigid Thermal Protection Systems
- Flexible Thermal Protection Systems
- Rigid Hypersonic Decelerators
- Deployable Hypersonic Decelerators

Descent
- Attached Deployable Decelerators
- Trailing Deployable Decelerators
- Supersonic Retropropulsion

Landing
- Touchdown Systems
- Egress & Deployment Systems
- Propulsion Systems
- Small Body Systems

Vehicle Systems Technology
- Separation Systems
- System Integration and Analyses
- Atmosphere & surface characterization
- Modeling and Simulation
- Instrumentation and Health Monitoring
- GN&C Sensors and Systems

TA10 • NANO-TECHNOLOGY

Engineered Materials & Structures
- Lightweight Structures
- Damage Tolerant Systems
- Coatings
- Adhesives
- Thermal Protection & Control

Energy Generation & Storage
- Energy Storage
- Energy Generation

Propulsion
- Propellants
- Propulsion Components
- In-Space Propulsion

Sensors, Electronics & Devices
- Sensors & Actuators
- Nanoelectronics
- Miniature Instruments

TA11 • MODELING, SIMULATION, INFORMATION TECHNOLOGY & PROCESSING

Computing
- Flight Computing
- Ground Computing

Modeling
- Software Modeling & Model-Checking
- Integrated Hardware & Software Modeling
- Human-System Performance Modeling
- Science Modeling
- Frameworks, Languages, Tools & Standards

Simulation
- Distributed Simulation
- Integrated System Lifecycle Simulation
- Simulation-Based Systems Engineering
- Simulation-Based Training & Decision Support Systems

Information Processing
- Science, Engineering & Mission Data Lifecycle
- Intelligent Data Understanding
- Semantic Technologies
- Collaborative Science & Engineering
- Advanced Mission Systems

TA12 • MATERIALS, STRUCTURES, MECHANICAL SYSTEMS & MANUFACTURING

Materials
- Lightweight Structure
- Computational Design
- Flexible Material Systems
- Environment
- Special Materials

Structures
- Lightweight Concepts
- Design & Certification Methods
- Reliability & Sustainment
- Test Tools & Methods
- Innovative, Multifunctional Concepts

Mechanical Systems
- Deployables, Docking and Interfaces
- Mechanism Life Extension Systems
- Electro-mechanical, Mechanical & Micromechanisms
- Design & Analysis Tools and Methods
- Reliability / Life Assessment / Health Monitoring
- Certification Methods

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- Manufacturing Processes
- Intelligent Integrated Manufacturing and Cyber Physical Systems
- Electronics & Optics Manufacturing Process
- Sustainable Manufacturing

Cross-Cutting
- Nondestructive Evaluation
- Model-Based Certification & Sustainment Methods
- Loads and Environments

TA13 • GROUND & LAUNCH SYSTEMS PROCESSING

Technologies to Optimize the Operational Life-Cycle
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- Environment-Hardened Materials and Structures
- Inspection, Anomaly Detection & Identification
- Fault Isolation and Diagnostics
- Prognostics Technologies
- Repair, Mitigation, and Recovery Technologies
- Communications, Networking, Timing & Telemetry

Technologies to Improve Mission Safety/Mission Risk
- Range Tracking, Surveillance & Flight Safety Technologies
- Landing & Recovery Systems & Components
- Weather Prediction and Mitigation
- Robotics / Telerobotics
- Safety Systems

TA14 • THERMAL MANAGEMENT SYSTEMS

Cryogenic Systems
- Passive Thermal Control
- Active Thermal Control
- Integration & Modeling

Thermal Control Systems
- Heat Acquisition
- Heat Transfer
- Heat Rejection & Energy Storage

Thermal Protection Systems
- Entry / Ascent TPS
- Plume Shielding (Convective & Radiative)
- Sensor Systems & Measurement Technologies

JSC SUPPLEMENTAL DATA

TA15 • AERONAUTICS

Aerosciences
- Propulsion Airframe Integration
- Drag Reduction
- Novel Configurations
- Propulsion Airframe Aero-acoustics
- Computational Methods
- Robust Aero
- Formation Flight
- Wake Vortex
- VSTOL/ESTOL
- Reduce/Mitigate Sonic Boom
- Multidisciplinary Design & Analysis Tools
- Efficient Hypersonic Aero

Propulsion and Power
- Quiet Propulsion
- Ultraclean Propulsion & Alternative Fuels
- Fuel Efficiency
- Propulsion for STOL/VTOL
- Supersonic Propulsion
- Combined Cycle Hypersonic
- Aero-Propulsion-Servo-Elasticity
- Robust Propulsion
- Hybrid Propulsion and Power
- Variable Cycle
- Advanced Concepts/ Alternative Engine Cycles
- Intelligent Engine
- Integrated Power Management

Dynamics, Control, Navigation, Guidance, and Avionics
- Advanced Guidance
- Distributed Decision, Uncertainty, &Flight Path
- Distributed Flow Control of Vehicle Dynamics
- Intelligent & Adaptive Control
- Fault-Tolerant IVHM
- On-Board Weather
- Pilot Vehicle Integration
- Synthetic & Enhanced Vision
- UAV in the NAS
- Advanced V&V Techniques
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- Advanced Communications

Intelligent & Human Integrated Systems, Ops, Decision Making & Networking
- Complex Interactive Systems
- Separation Assurance
- Wake Vortex systems
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- Adaptive Air Traffic Control for Adverse Weather
- Collaborative Decision Systems
- Operational Maintenance Data
- Task & Attention Management
- Environmentally Friendly Aviation
- Super Density Operations

TA16 • ORBITAL DEBRIS AND HYPERVELOCITY IMPACT

Orbital Debris
- Modeling
- Monitoring
- Mitigation
- Remediation

Hypervelocity Impact
- Material Composition
- Experimental Investigations

TA17 • EMERGING TECHNOLOGIES

Space Technology Roadmaps STR • TABS
TECHNOLOGY AREA BREAKDOWN STRUCTURE

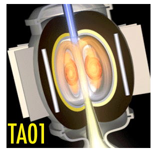
REVISED—08/10/12

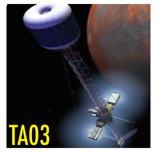
Note: Evaluation is based upon competitive, commercial market potential over next decade and thus must demonstrate unique value and advance state of the art in a commercial market

PARTNERSHIP POTENTIAL – JSC PERSPECTIVE

National Aeronautics and Space Administration

OFFICIAL NASA ROADMAPS





TA01 • LAUNCH PROPULSION SYSTEMS

Solid Rocket Propulsion Systems
- Propellants
- Case Materials
- Nozzle Systems
- Hybrid Rocket Propulsion Systems
- Fundamental Solid Propulsion Technologies

Liquid Rocket Propulsion Systems
- LH_2/LOX Based
- RP/LOX Based
- CH_4/LOX Based
- Detonation Wave Engines (Closed Cycle)
- Propellants
- Fundamental Liquid Propulsion Technologies

Air Breathing Propulsion Systems
- TBCC
- RBCC
- Detonation Wave Engines (Open Cycle)
- Turbine Based Jet Engines (Flyback Boosters)
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- Deeply-cooled Air Cycles
- Air Collection & Enrichment System
- Fundamental Air Breathing Propulsion Technologies

Ancillary Propulsion Systems
- Auxiliary Control Systems
- Main Propulsion Systems (Excluding Engines)
- Launch Abort Systems
- Thrust Vector Control Systems
- Health Management & Sensors
- Pyro & Separation Systems
- Fundamental Ancillary Propulsion Technologies

Unconventional / Other Propulsion Systems
- Ground Launch Assist
- Air Launch / Drop Systems
- Space Tether Assist
- Beamed Energy / Energy Addition
- Nuclear
- High Energy Density Materials/Propellants

TA02 • IN-SPACE PROPULSION TECHNOLOGIES

Chemical Propulsion
- Liquid Storable
- Liquid Cryogenic
- Gels
- Solid
- Hybrid
- Cold Gas/Warm Gas
- Micro-propulsion

Non-Chemical Propulsion
- Electric Propulsion
- Solar Sail Propulsion
- Thermal Propulsion
- Tether Propulsion

Advanced (TRL <3) Propulsion Technologies
- Beamed Energy Propulsion
- Electric Sail Propulsion
- Fusion Propulsion
- High Energy Density Materials
- Antimatter Propulsion
- Advanced Fission
- Breakthrough Propulsion

Supporting Technologies
- Propellant Storage & Transfer

TA03 • SPACE POWER & ENERGY STORAGE

Power Generation
- Energy Harvesting
- Chemical (Fuel Cells, Heat Engines)
- Solar (Photo-Voltaic & Thermal)
- Radioisotope
- Fission
- Fusion

Energy Storage
- Batteries
- Flywheels
- Regenerative Fuel Cells

Power Management & Distribution
- FDIR
- Management & Control
- Distribution & Transmission
- Wireless Power Transmission
- Conversion & Regulation

Cross Cutting Technology
- Analytical Tools
- Green Energy Impact
- Multi-functional Structures
- Alternative Fuels

TA04 • ROBOTICS, TELE-ROBOTICS & AUTONOMOUS SYSTEMS

Sensing & Perception
- 3-D Perception
- Relative Position & Velocity Estimation
- Terrain Mapping, Classification & Characterization
- Natural & Man-made Object Recognition
- Sensor Fusion for Sampling & Manipulation
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Mobility
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- Below-Surface Mobility
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- Robot Arms
- Dexterous Manipulators
- Modeling of Contact Dynamics
- Mobile Manipulation
- Collaborative Manipulation
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- Multi-Modal Human-Systems Interaction
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- Autonomous Guidance & Control
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- Adjustable Autonomy
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Autonomous Rendezvous & Docking
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- Modularity/Commonality
- Verification & Validation of Complex Adaptive Systems
- Onboard Computing

TA05 • COMMUNICATION & NAVIGATION

Optical Comm. & Navigation
- Detector Development
- Large Apertures
- Lasers
- Acquisition & Tracking
- Atmospheric Mitigation

Radio Frequency Communications
- Spectrum Efficient Technologies
- Power Efficient Technologies
- Propagation
- Flight & Ground Systems
- Earth Launch & Reentry Comm.
- Antennas

Internetworking
- Disruptive Tolerant Networking
- Adaptive Network Topology
- Information Assurance
- Integrated Network Management

Position, Navigation, and Timing
- Timekeeping & Time Distribution
- Onboard Auto Navigation & Maneuver
- Sensors & Vision Processing Systems
- Relative & Proximity Navigation
- Auto Precision Formation Flying
- Auto Approach & Landing

Integrated Technologies
- Radio Systems
- Ultra Wideband
- Cognitive Networks
- Science from the Comm. System
- Hybrid Optical Comm. & Navigation Sensors
- RF/Optical Hybrid Technology

Revolutionary Concepts
- X-Ray Navigation
- X-Ray Communications
- Neutrino-Based Nav. & Tracking
- Quantum Key Distribution
- Quantum Communications
- SQIF Microwave Amplifier
- Reconfigurable Large Apertures Using Nanosat Constellations

TA06 • HUMAN HEALTH, LIFE SUPPORT & HABITATION SYSTEMS

Environmental Control & Life Support Systems & Habitation Systems
- Air Revitalization
- Water Recovery & Management
- Waste Management
- Habitation

Extravehicular Activity Systems
- Pressure Garment
- Portable Life Support System
- Power, Avionics & Software

Human Health & Performance
- Medical Diagnosis / Prognosis
- Long-Duration Health
- Behavioral Health
- Human Factors

Environmental Monitoring, Safety & Emergency Response
- Sensors: Air, Water, Microbial, etc.
- Fire: Detection, Suppression, Recovery
- Protective Clothing / Breathing
- Remediation

Radiation
- Risk Assessment Modeling
- Radiation Mitigation
- Protection Systems
- Radiation prediction
- Monitoring Technology

TA07 • HUMAN EXPLORATION DESTINATION SYSTEMS

In-Situ Resource Utilization
- Destination Reconnaissance, Prospecting, & Mapping
- Resource Acquisition
- Consumables Production
- Manufacturing Products & Infrastructure Emplacement

Sustainability & Supportability
- Autonomous Logistics Management
- Maintenance Systems
- Repair Systems
- Food Production, Processing, & Preservation

"Advanced" Human Mobility Systems
- EVA Mobility
- Surface Mobility
- Off-Surface Mobility

"Advanced" Habitat Systems
- Integrated Habitat Systems
- Habitat Evolution
- "Smart" Habitats
- Artificial Gravity

Mission Operations & Safety
- Crew Training
- Planetary Safety
- Integrated Flight Operations Systems
- Integrated Risk Assessment Tools

Cross-Cutting Systems
- Construction & Assembly
- Particulate Contamination Prevention & Mitigation

TA08 • SCIENCE INSTRUMENTS, OBSERVATORIES & SENSOR SYSTEMS

Remote Sensing Instruments/Sensors
- Detectors & Focal Planes
- Electronics
- Optical Components
- Microwave / Radio
- Lasers
- Cryogenic / Thermal

Observatories
- Mirror Systems
- Structures & Antennas
- Distributed Aperture

In-Situ Instruments/Sensor
- Particles: Charged & Neutral
- Fields & Waves
- In-Situ

TA09 • ENTRY, DESCENT & LANDING SYSTEMS

Aeroassist & Atmospheric Entry
- Rigid Thermal Protection Systems
- Flexible Thermal Protection Systems
- Rigid Hypersonic Decelerators
- Deployable Hypersonic Decelerators

Descent
- Attached Deployable Decelerators
- Trailing Deployable Decelerators
- Supersonic Retropropulsion

Landing
- Touchdown Systems
- Egress & Deployment Systems
- Propulsion Systems
- Small Body Systems

Vehicle Systems Technology
- Separation Systems
- System Integration and Analyses
- Atmosphere & surface characterization
- Modeling and Simulation
- Instrumentation and Health Monitoring
- GN&C Sensors and Systems

TA10 • NANO-TECHNOLOGY

Engineered Materials & Structures
- Lightweight Structures
- Damage Tolerant Systems
- Coatings
- Adhesives
- Thermal Protection & Control

Energy Generation & Storage
- Energy Storage
- Energy Generation

Propulsion
- Propellants
- Propulsion Components
- In-Space Propulsion

Sensors, Electronics & Devices
- Sensors & Actuators
- Nanoelectronics
- Miniature Instruments

TA11 • MODELING, SIMULATION, INFORMATION TECHNOLOGY & PROCESSING

Computing
- Flight Computing
- Ground Computing

Modeling
- Software Modeling & Model-Checking
- Integrated Hardware & Software Modeling
- Human-System Performance Modeling
- Science Modeling
- Frameworks, Languages, Tools & Standards

Simulation
- Distributed Simulation
- Integrated System Lifecycle Simulation
- Simulation-Based Systems Engineering
- Simulation-Based Training & Decision Support Systems

Information Processing
- Science, Engineering & Mission Data Lifecycle
- Intelligent Data Understanding
- Semantic Technologies
- Collaborative Science & Engineering
- Advanced Mission Systems

TA12 • MATERIALS, STRUCTURES, MECHANICAL SYSTEMS & MANUFACTURING

Materials
- Lightweight Structure
- Computational Design
- Flexible Material Systems
- Environment
- Special Materials

Structures
- Lightweight Concepts
- Design & Certification Methods
- Reliability & Sustainment
- Test Tools & Methods
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- Manufacturing Processes
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- Electronics & Optics Manufacturing Process
- Sustainable Manufacturing

Cross-Cutting
- Nondestructive Evaluation
- Model-Based Certification & Sustainment Methods
- Loads and Environments

TA13 • GROUND & LAUNCH SYSTEMS PROCESSING

Technologies to Optimize the Operational Life-Cycle
- Storage, Distribution & Conservation of Fluids
- Automated Alignment, Coupling, & Assembly Systems
- Autonomous Command & Control for Ground and Integrated Vehicle / Ground Systems

Environmental and Green Technologies
- Corrosion Prevention, Detection, & Mitigation
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- Preservation of Natural Eco-systems
- Alternate Energy Prototypes

Technologies to Increase Reliability and Mission Availability
- Advanced Launch Technologies
- Environment-Hardened Materials and Structures
- Inspection, Anomaly Detection & Identification
- Fault Isolation and Diagnostics
- Prognostics Technologies
- Repair, Mitigation, and Recovery Technologies
- Communications, Networking, Timing & Telemetry

Technologies to Improve Mission Safety/Mission Risk
- Range Tracking, Surveillance & Flight Safety Technologies
- Landing & Recovery Systems & Components
- Weather Prediction and Mitigation
- Robotics / Telerobotics
- Safety Systems

TA14 • THERMAL MANAGEMENT SYSTEMS

Cryogenic Systems
- Passive Thermal Control
- Active Thermal Control
- Integration & Modeling

Thermal Control Systems
- Heat Acquisition
- Heat Transfer
- Heat Rejection & Energy Storage

Thermal Protection Systems
- Entry / Ascent TPS
- Plume Shielding (Convective & Radiative)
- Sensor Systems & Measurement Technologies

JSC SUPPLEMENTAL DATA

TA15 • AERONAUTICS

Aerosciences
- Propulsion Airframe Integration
- Drag Reduction
- Novel Configurations
- Propulsion Airframe Aero-acoustics
- Computational Methods
- Robust Aero
- Formation Flight
- Wake Vortex
- VSTOL/ESTOL
- Reduce/Mitigate Sonic Boom
- Multidisciplinary Design & Analysis Tools
- Efficient Hypersonic Aero

Propulsion and Power
- Quiet Propulsion
- Ultraclean Propulsion & Alternative Fuels
- Fuel Efficiency
- Propulsion for STOL/VTOL
- Supersonic Propulsion
- Combined Cycle Hypersonic
- Aero-Propulsion-Servo-Elasticity
- Robust Propulsion
- Hybrid Propulsion and Power
- Variable Cycle
- Advanced Concepts/ Alternative Engine Cycles
- Intelligent Engine
- Integrated Power Management

Dynamics, Control, Navigation, Guidance, and Avionics
- Advanced Guidance
- Distributed Decision, Uncertainty, &Flight Path
- Distributed Flow Control of Vehicle Dynamics
- Intelligent & Adaptive Control
- Fault-Tolerant IVHM
- On-Board Weather
- Pilot Vehicle Integration
- Synthetic & Enhanced Vision
- UAV in the NAS
- Advanced V&V Techniques
- Load, Vibration & Stability Control
- Advanced Communications

Intelligent & Human Integrated Systems, Ops, Decision Making & Networking
- Complex Interactive Systems
- Separation Assurance
- Wake Vortex systems
- Architecture Vulnerability Analysis for Air Traffic Control
- Adaptive Air Traffic Control for Adverse Weather
- Collaborative Decision Systems
- Operational Maintenance Data
- Task & Attention Management
- Environmentally Friendly Aviation
- Super Density Operations

TA16 • ORBITAL DEBRIS AND HYPERVELOCITY IMPACT

Orbital Debris
- Modeling
- Monitoring
- Mitigation
- Remediation

Hypervelocity Impact
- Material Composition
- Experimental Investigations

TA17 • EMERGING TECHNOLOGIES

Space Technology Roadmaps

STR • TABS
TECHNOLOGY AREA BREAKDOWN STRUCTURE

REVISED—08/14/12

Appendix B

FY’12 Center Innovation Fund Supported Project Charts

Appendix B

FY'12 Center Innovation Fund Supported Projects

JSC Center-Level Internal Research & Development Projects

Project Title	P.I.	Notional TA Roadmap Crosswalk	CIF FTEs	CIF Procurement / Travel	Notes
Game Changing Augmented Reality Training and Assistance for Maintenance Repair	Lui Wang	4.4, 4.5, 6.3, 7.5	1.00		Leveraged with $100.0K CM&O Resources
Mini Total Organic Carbon Analyzer (miniTOCA)	Dr. Paul Mudgett	6.1, 6.2, 6.3	0.25		Leveraged with $100.0K CM&O Resources
Multifunctional Composite Structure Phase II	David R. Lowry	12.2.2	1.00		Leveraged with $100.0K CM&O Resources
Sensor Risk Mitigation Technology Development for ADR	Anthony Griffith	4, 5, 11	0.85		Leveraged with $100.0K CM&O Resources
Spacesuit Evaporator-Absorber-Radiator (SEAR)	Grant C. Bue	6	0.40		Leveraged with $99.3K CM&O Resources
In-Space Manufacturing Development and Demonstration	Michael Waid	12.2	1.00		Leveraged with $100.0K CM&O Resources
Development of a Wide-Spectrum Organic Analysis Instrument	Scott Messenger	8	0.50		Leveraged with $85.0K CM&O Resources
Brine Recovery in Containment (BRIC)	Karen D Pickering	6.2.1	1.00		Leveraged with $100.0K CM&O Resources
Hybrid Li-ion Supercapacitor/Li-ion Battery System for Extended Performance	J. Jeevarajan	2, 3, 4	0.60		Leveraged with $100.0K CM&O Resources
A Ground Testbed to Advance US Capability in Autonomous Rendezvous and Docking	C D'Souza	4, 5, 11	1.00		Leveraged with $100.0K CM&O Resources
Active Radiation Shielding Utilizing High Temperature Superconducting Magnets	Shayne Westover	6, 7	1.00		
Miniature Exercise Device (MED)	Cherice Moore	6, 12	1.00		
Multi-Phase Methane Heat Transfer Testing/Modeling for Regenerative Cooling	John "J.C." Melcher	2.1.2.1	1.00		
CIF Total for Center-Level IR&D Projects			**10.60**	**0**	Leveraged with $984.3K CM&O Resources

FY’12 Center Innovation Fund Supported Projects

JSC Directorate-Level Internal Research & Development Projects					
Project Title	**P.I.**	**Notional TA Roadmap Crosswalk**	**CIF FTEs**	**CIF Procurement / Travel**	**Notes**
Multi-Phase Flow Experiment for Suborbital Testing	Katy Hurlbert	2.0, 3.0, 6.0, 7.0, 14.0	0.50		Leveraged with $50.0K CM&O Resources
LOX/Methane Regeneratively-Cooled Rocket Engine Development	Robert Morehead	2.1	1.00		Leveraged with $100.0K CM&O Resources
Flight Deck of the Future: e-textile iGear Flight Deck of the Future: Virtual Windows	Cory Simon & Helen Neighbors	4.0, 5.0, 6.0, 7.0, 12.1, 12.2, 12.3,	1.40		Leveraged with $90.0K CM&O Resources
GeoLab Sample Handling System	Cindy Evans	4.4, 7.4, 8.0, 11.1, 11.2,	0.10		Leveraged with $25.0K CM&O Resources
Curation Technology for Future Sample Return Missions	Carlton Allen	7, 8	0.10		Leveraged with $30.0K CM&O Resources
Habitat Particle Impact Monitoring System	John Opiela & Eugene Stansbery	7.4, 7.5	0.30		Leveraged with $40.0K CM&O Resources
GIS Technology: Resource and Habitability Assessment Tool	Carlton Allen	7.1	0.10		Leveraged with $20.0K CM&O Resources
Ionic Monopropellant Contamination and Det.	Mark McClure	2.1	0.10		Leveraged with $40.0K CM&O Resources
Microgravity Cell Counter: A Simple Hand-held Low-cost Device for In-flight WBC/Differential	Brian Crucian	6.3	0.34		Leveraged with $11.1K CM&O Resources
CIF Total for Directorate-Level IR&D Projects			**3.90**	**0**	Leveraged with $406.1K CM&O Resources

FY'12 Center Innovation Fund Supported Projects

JSC Innovation Charge Account Projects					
Project Title	**P.I.**	**Notional TA Roadmap Crosswalk**	**CIF FTEs**	**CIF Procurement / Travel**	**Notes**
Electrospray Ionization for Water Monitoring	William T. Wallace	6.4		$10.0K	
Testbed For Aerothermal Test Technique Development	A. Brandon Oliver	11.3		$8.0K	
Rocket Fuel Synthesis by Fisher-Tropsch Process	Rama K. Allada	2.1		$6.4K	
Modeling Limbless Locomotion using ADAMS Software	Prashant S. Rao	11.2		$10.0K	
Pitch Synchronous Segmentation of Speech Signals	Aniko Sandor	5.2		$8.5K	
Augmented Reality to Enhance Crew Medical Training	Lui Wang	11.1		$15.0K	
Parachute Cord Tension Sensor	Satish C. Reddy	9.3		$10.0K	
Unmanned Micro-g Flight Program	Matthew Hart	11.3		$10.0K	
Non-Powered Spectrophotometry for Lighting	Toni Anne Clark	Not Applicable to Spring Call		$9.0K	
Coupled Human-Space Suit Mobility Studies	Lindsay T. Aitchison	Not Applicable to Spring Call		$10.0K	
A Novel Scheme for Spacecraft Manual Control	Stan G. Love	Not Applicable to Spring Call		$3.0K	Leveraged with CM&O FTE
Novel Ultrasound Assessment of Dynamic Muscle	Jessica Scott	Not Applicable to Spring Call		$10.0K	
Crew Health And Recreation Gear Exercise Device	Michael Li	Not Applicable to Spring Call		$10.0K	
Compact Termination for Structural Soft-goods	Robert Wilkes Jr.	Not Applicable to Spring Call		$10.0K	
Inside-Out Manufacturing of Composite Structures	Charles S. Hill	Not Applicable to Spring Call		$6.0K	Leveraged with CM&O FTE
Future Autonomous and Automated Systems Testbed	Angela Lenort	Not Applicable to Spring Call		$10.0K	
Interface Anywhere	Max Haddock	Not Applicable to Spring Call		$10.0K	
Gesture Commanding of a Robot with EVA Gloves	Neta Ezer	Not Applicable to Spring Call		$10.0K	
Stitched Camera Array for Clearance Monitoring	Zachary Drewry	Not Applicable to Spring Call		$10.0K	
A solar powered, ceramic oxygen concentrator	John Graf	Not Applicable to Spring Call		$9.2K	
Radiation mitigation theory	Carl Swopes	Not Applicable to Spring Call		$11.5K	
Instrumented Suit HUT for Ergonomic Assessment	Sudhakar Rajulu	Not Applicable to Spring Call		$9.3K	Leveraged with CM&O FTE
Textile Strain Gauge for Inflatable Structures	Doug Litteken	Not Applicable to Spring Call		$7.0K	Leveraged with CM&O FTE
Ion Mobility Spectrometry for Water Monitoring	William T. Wallace	Not Applicable to Spring Call		$10.0K	
Variable property fluids for dynamic environments	Thomas J Cognata	Not Applicable to Spring Call		$9.6K	
Nano-Antenna For Terahertz Medical Imaging	Shian Hwu	Not Applicable to Spring Call		$10.0K	
An Electrochemical Approach to ID Bacteria	Daniel P. Gazda	Not Applicable to Spring Call		$10.0K	
Integration of Voice and Gesture	David Overland	Not Applicable to Spring Call		$6.0K	
Dilatant Material For Advanced Exercise Equipment	Phil Callen	Not Applicable to Spring Call		$8.0K	
Hybrid Windows and Mosaic Video	Helen Neighbors	Not Applicable to Spring Call		$7.0K	Leveraged with CM&O FTE
Single-sided Temporary Adhesion in Zero-G	George Studor	Not Applicable to Spring Call		$0.5K	Leveraged with CM&O FTE
CIF Total For ICA Projects			**0**	**$274.0K**	

CIF Totals for FY12 Supported Projects at JSC **FTEs: 14.5** **CIF Procurement/Travel: $274.0K**

Appendix C

JSC FY’12 CIF Support Project Details
Center-Level IR&D

Game Changing Augmented Reality Training and Assistance for Maintenance Repair

PROJECT MANAGEMENT

Lui Wang / ER; 281-483-8074 & lui.wang-1@nasa.gov
Collaboration: Douglas Wong/SF Human Engineering; Robert Tweety/SD ARED Instructor

Project Overview

Research and Develop Augmented Reality (AR) electronic procedure system (AR-eProc). Combines Hardware, Software, & Procedure Content to create a new user experience to perform maintenance repair tasks that could dramatically improve human performance and situational awareness.

Relevance / Value to NASA

NASA consistently searches for efficiencies in astronaut training. The portable, AR-eProc system will:

- Enable self-sustaining autonomous operations
- Increase crew autonomy and reduce crew reliance of ground and electronic paper based procedures
- Increase crew task efficiency and performance
- Reduce human error

Objectives & Outcomes

The objectives were to:

- Improve the robustness of vision tracking and image registration
- Improve the over all system packing, usability and hardware/software
- Assess feasibility to leverage GPGPU supercomputing capability

The outcomes of the project were:

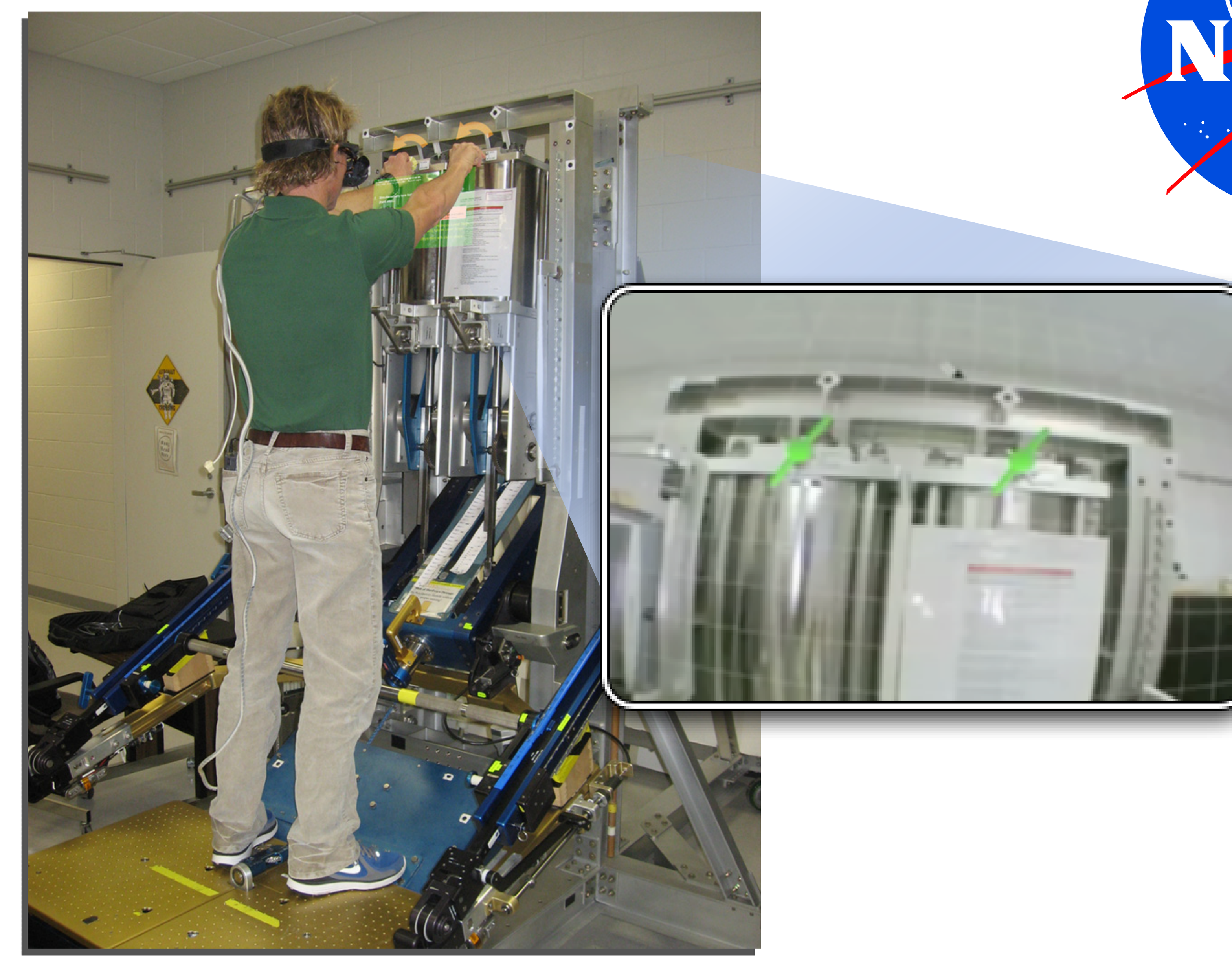
- Identified and evaluated new COTS AR hardware software
- Identified and evaluated new COTS Head Mounted Display technologies
- Refactored AR vision tracking and registration algorithms for GPU based computation

Infusion Potential

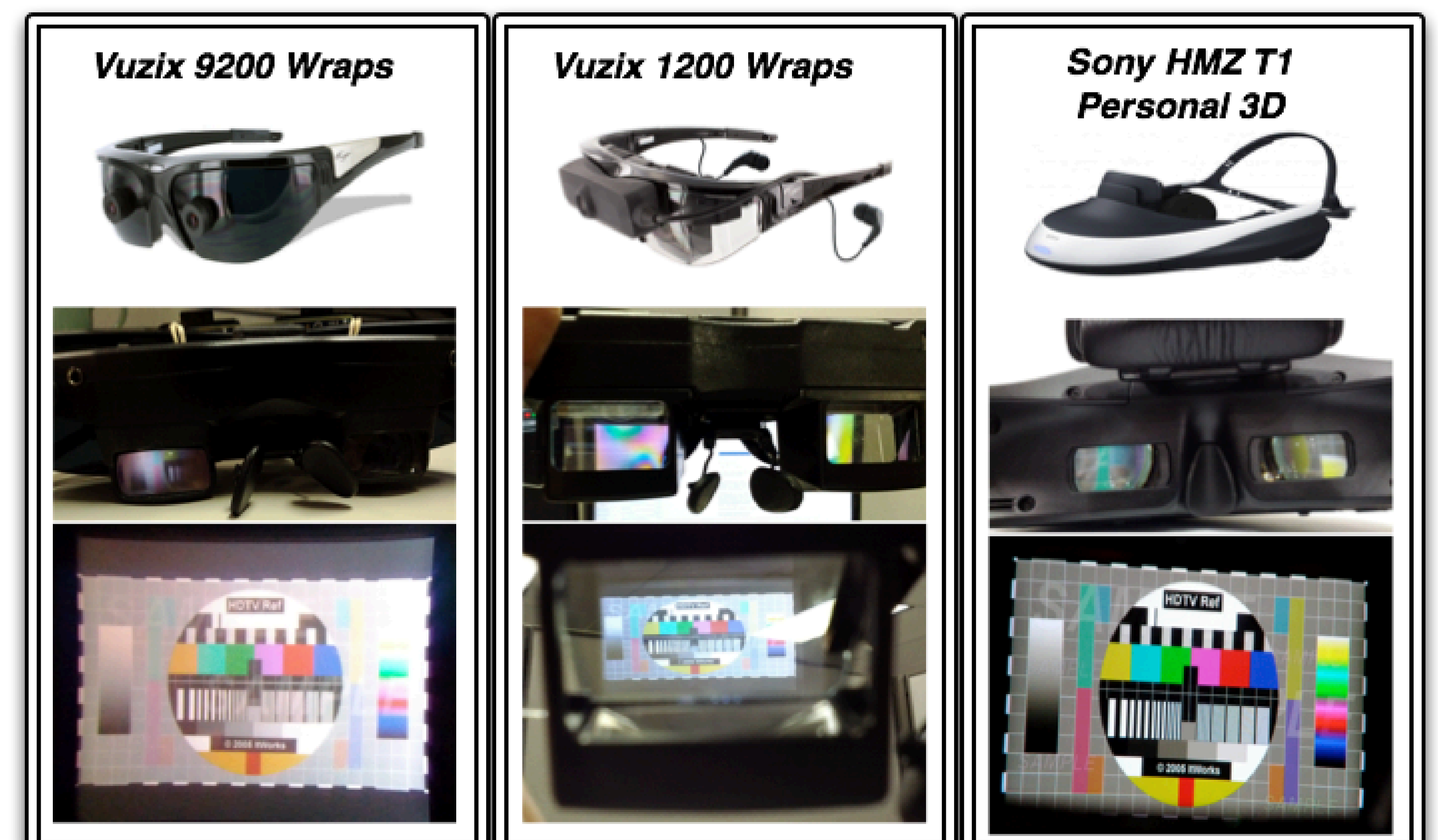
The technology will be matured and infused through series of demonstration with increasing fidelity from ISS training facility to on-orbit ISS DTO demonstrations. The ISS Program is striving to minimize crew time spent on training and reliance on ground support for operations.

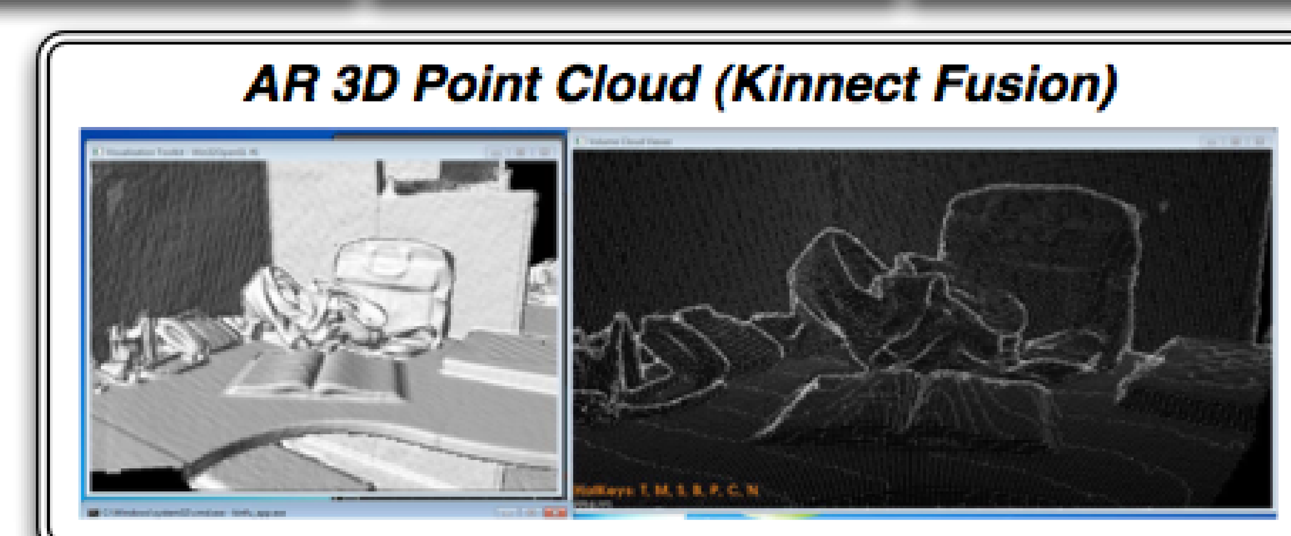
NASA Technology Area Roadmap

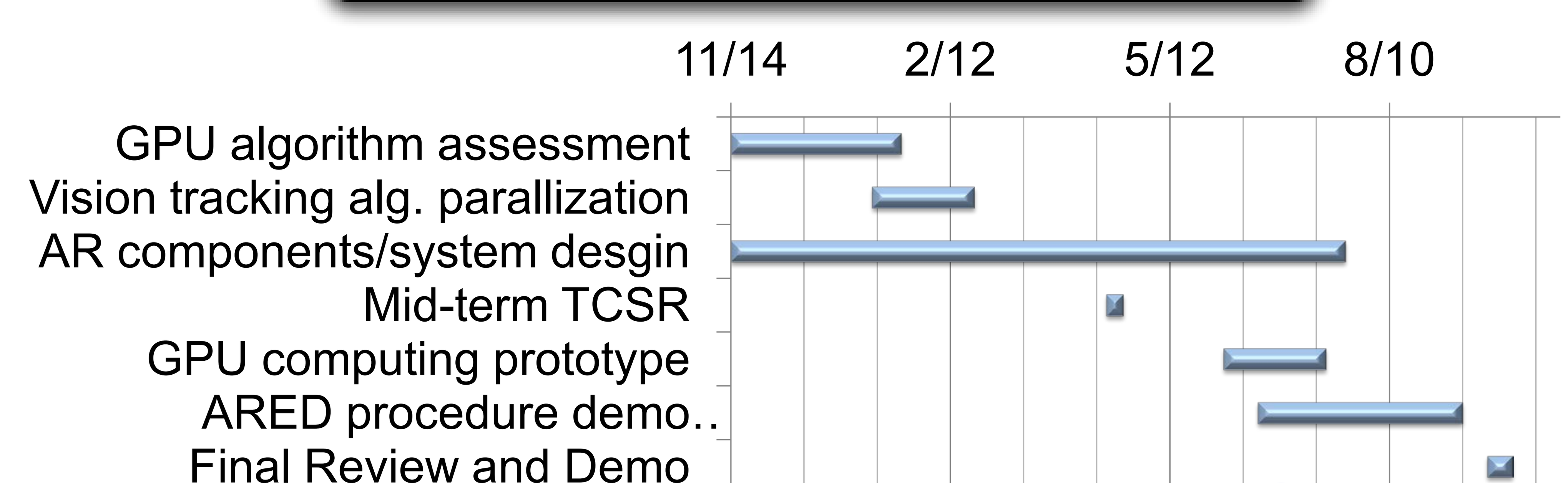
- 4.0/4.4 Human Systems Interaction (Just-in-Time human performance support),
- 4.0/4.5 Autonomy (enable crew autonomous operation and reduce dependency on ground support),
- 6.0/6.3 Human Health and Performance (enhance situational awareness, reduce cognitive overload),
- 7.0/7.5 Mission Operations & Safety (reduce human error, improve operational efficiency).



HMD Evaluation - Image Quality Comparison







Project Start TRL: 3
FinishTRL : 5

Mini Total Organic Carbon Analyzer-TOCA

PROJECT MANAGEMENT
Paul Mudgett/SF2 with Anna Clements/EC3
281-483-8766/paul.d.mudgett@nasa.gov

PROJECT OVERVIEW

- MiniTOCA project seeks to miniaturize and drastically simplify the TOCA water quality monitor to cut consumables, reduce power by 90% and reduce mass-volume footprint by 95%.

RELEVANCE/ VALUE TO NASA

- The water supply on longer term deep space missions will be recycled water. Like on ISS, TOCA is required to verify recycled water purity, but the Exploration TOCA will need to be small (hand-held).

OBJECTIVES & OUTCOMES

- With industry partner OI Analytical of College Station and Bioastronautics staff we are iteratively designing and testing subsystems, breadboarding, then calibrating to analyze water samples.
- The primary product of this first year of development will be a report, but early breadboards may be available for demo.

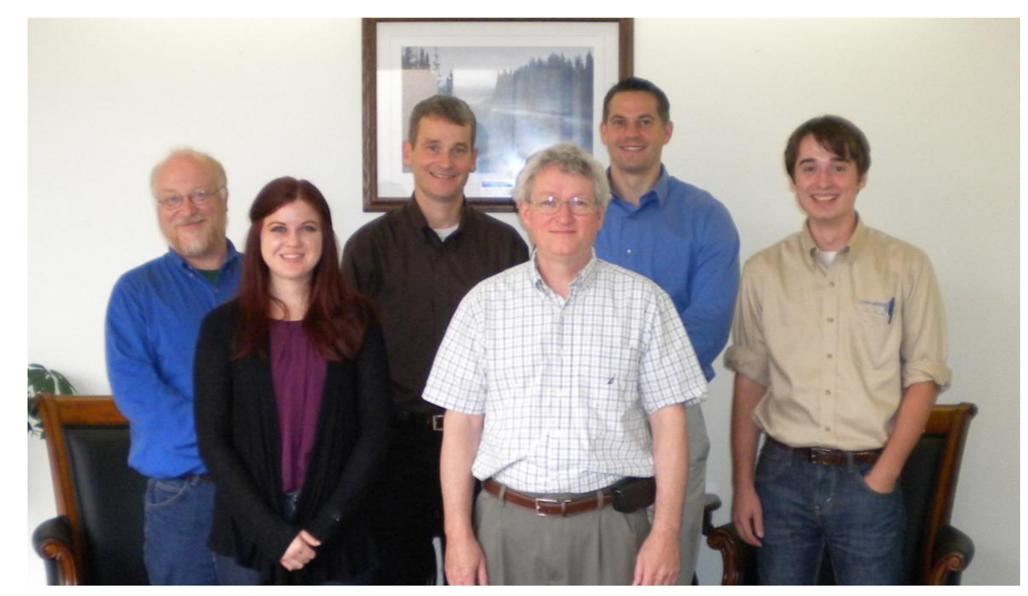
INFUSION POTENTIAL

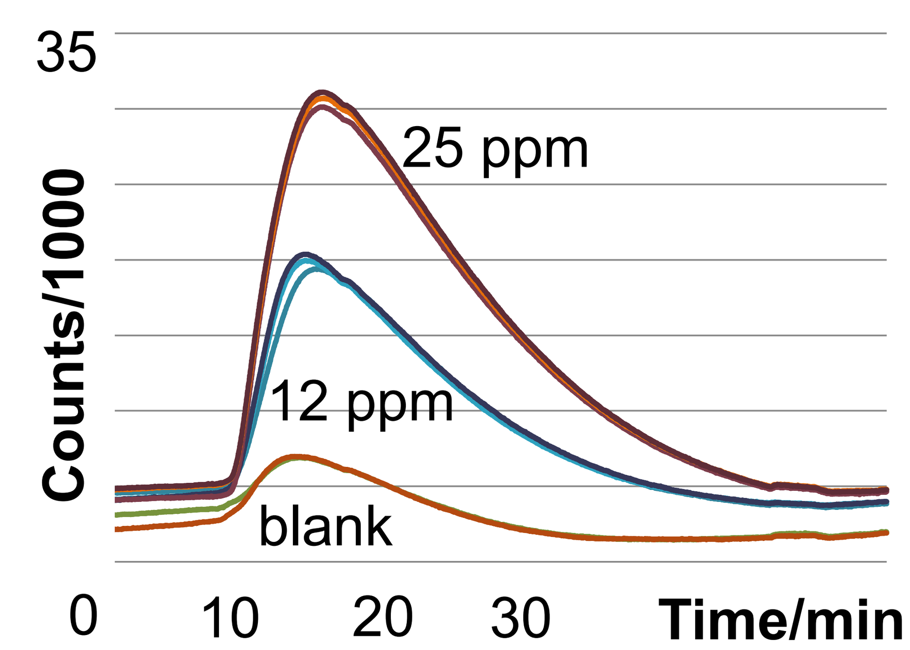
- ISS provides a perfect opportunity to validate MiniTOCA using real recycled water as an FY14-15 Tech Demo. This allows time for operational hardware to be built for deep space Exploration missions.
- OI Analytical created a commercial bench top TOCA from the reactor invented during ISS TOCA development. We envision a similar commercial development for a highly miniaturized TOCA.

The Vision

Current State of Art
ISS TOCA
Mass: 34 kg
Volume: 67 L
Power: 64 W

The Team (L to R)
Karl Williams/OI
Heather Mera/Wyle
Paul Mudgett/NASA
Don Segers/OI
Jeff Milstead/L-M
Eli Williams/OI





Data:
TOC solution challenges for Breadboard 2.0

NASA TECHNOLOGY ROADMAP

- This project is directly applicable to TA-06 *Human Health, Life Support, and Habitation Systems*, aligning specifically with 6.4 *Environmental Monitoring, Safety, and Emergency Response.*

PROJECT DEVELOPMENT SCHEDULE

Major Tasks & Reviews	Nov	Jan	Mar	Apr	Jul	Aug	Sep
Kickoff & Team Meetings	7th	17th	13th	26th	13th	17th	7th
JTWG detailed TCSR #1				17th			
Design & Develop Subsystems	■■	■■	■■				
Test and Optimize Subsystems			■■	■■			
Build & optimize breadboards				■■	■■		
2012 IR&D Poster Session						7th	
Test integrated breadboard 3.0						■■	■■
Final report & demonstration							■■
JTWG detailed TCSR #2							27th

Project Start TRL (1-9): 2
Current TRL (1-9): 3

Multifunctional Composite Structure

PROJECT MANAGEMENT

Innovator: **David Lowry, JSC ES-2 (281) 483-0272 david.r.lowry@nasa.gov**

Collaborators: Dr. Eric Christiansen JSC-KX, Dr. Steven Koontz JSE-ES, Dr. Shantaram Pai, GRC-SXO, Dr. Ethiraj Venkatapathy ARC-TS, Dr. Alan Parker DRC-RS (Collaborators are on Global)

PROJECT OVERVIEW This Phase II project is developing a Composite Sandwich Habitable Pressurized Structure for deep space travel. Permeability, Radiation, & MM/OD shielding are built into the structure; along with fiber optic sensor technology for Structural & Thermal Health Monitoring. 3-D woven fabric and bonded window technologies are being developed in concert for a complete habitable composite system. To enable this technology & help prepare a clear path to certification, material system modeling and probabilistic design & analysis are also being developed.

RELEVANCE/ VALUE TO NASA This project addresses the critical need for multifunctional deep space structure (lightweight, compact, robust, shielding (radiation/MM/OD, Permeability), & informative (Structural health monitoring) as described in the TA-12 Oct Roadmap Report, and confirmed by the NRC.

OBJECTIVES & OUTCOMES

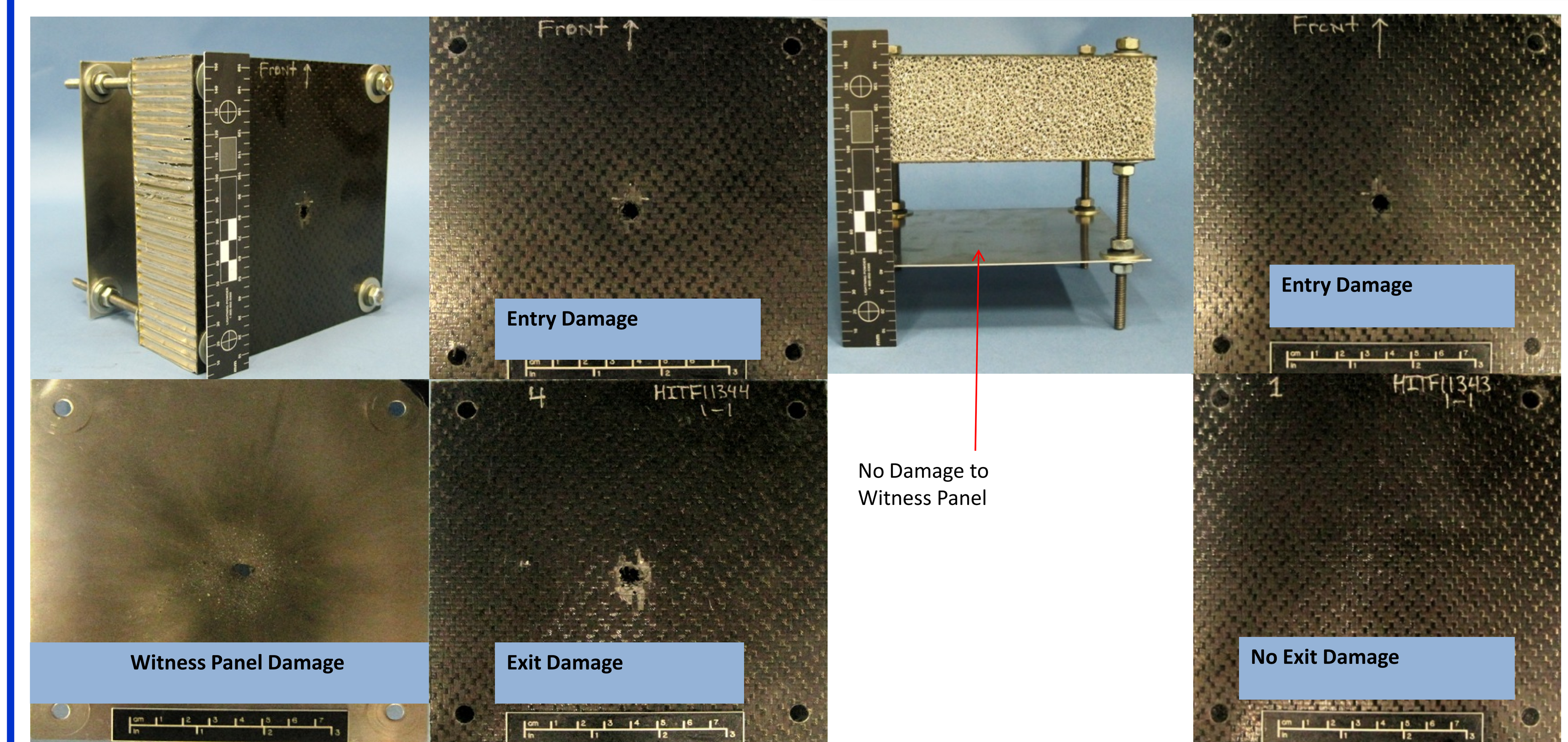
On track for a Phase III to narrow parameters during Phase II and then begin producing demonstrators with notable capability at significant weight savings.

Further narrow design parameters to enable TRL advancement toward production

Products include test data, demo hardware, test results, & reports

INFUSION POTENTIAL Part of MMSEV AES, supports DSH AES, tied to DRC test development and ARC Composite Heat shield Development, OCT Composite Heat Shield, Chrysler Motors is working on disclosure agreement and the Navy is interested.

Honeycomb Panel (HITF11343/Test #2) Metallic Foam Panel (HITF11343/Test #1)



NASA TECHNOLOGY AREA ROADMAP

12.2.2.1.1 Lightweight Concepts (Non-Autoclave Primary Structure)
12.2.2.2.3 Design & Certi Methods (Probabilistic Design/ Rapid Mat'l Dev)
12.2.2.3.3 Reliability & Sustainment (Heath Monitoring-embedded sensors)
12.2.2.5.2 & 6 Innovative, Multifunctional Concepts (Integrated MM/OD /Radiation/Permeability

PROJECT DEVELOPMENT SCHEDULE

Project Development Schedule:	1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
Structural testing/model correlation (.025 WYE)				
Low ρ Specimen Mfg, Test (0.1 FTE)				
Probabilistic Material Property Dev. (1.0 FTE)				
Formability/Out of Autoclave Dev. ($1K)				
Radiation Analysis and Testing ($7K)				
Bonded Windows				
Begin Embedded SHM system ($20K)				
Mid –Term and Final Reports			❖	❖

Sensor Risk Mitigation Technology Development for ADR

PROJECT MANAGEMENT

Anthony Griffith, EA3, 281-244-5813, anthony.d.griffith@nasa.gov
Dr. Brian Kent AFRL/RY, (937) 528-8831,brian.kent@wpafb.af.mil
Dr. John Junkins, Texas A&M University, (979) 845-3912, junkins@tamu.edu

PROJECT OVERVIEW

This project is developing and maturing Active Debris Removal (ADR) spacecraft sensors and techniques to dramatically reduce the weight, power, complexity and cost over existing means. The project is producing an autonomous, high speed, and un-tethered air bearing sled system capable of 3-DOF ground testing for this purpose.

RELEVANCE/ VALUE TO NASA

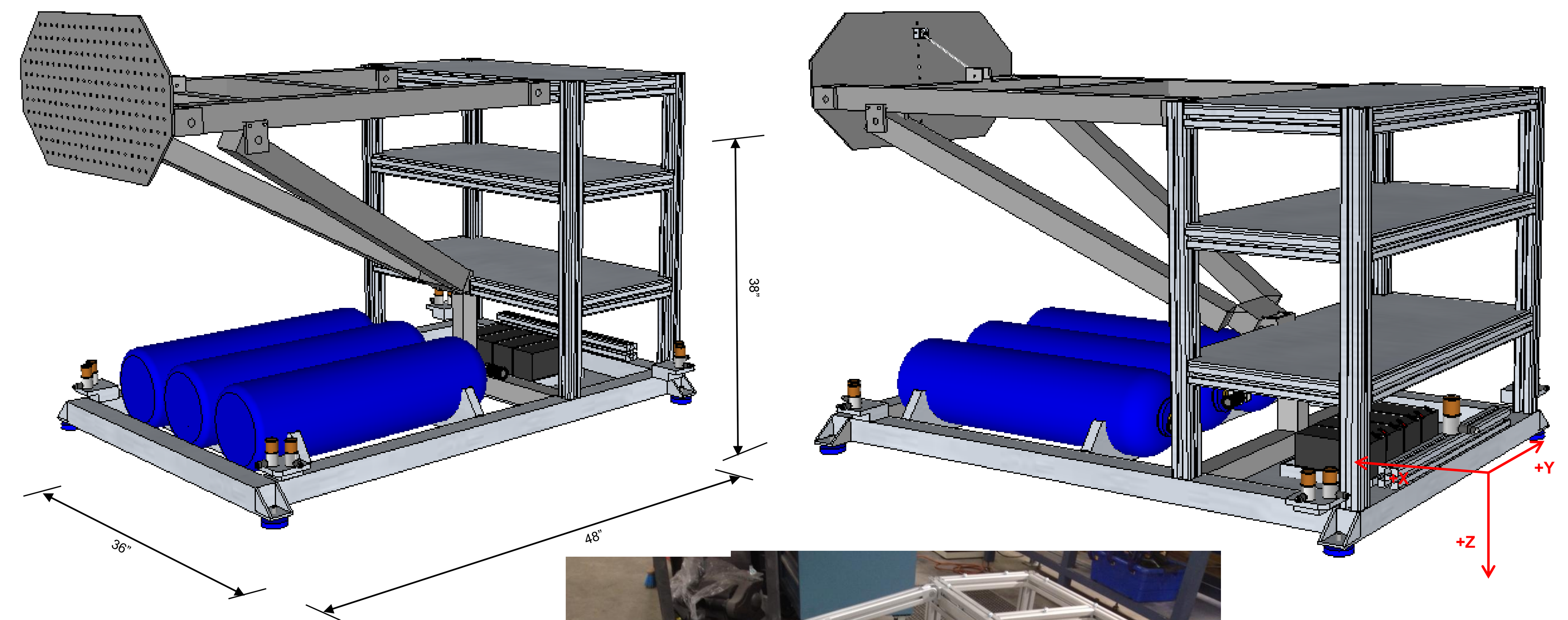
- The sled system has applications far broader than the debris mission – potentially to any vehicle which performs rendezvous and docking operations, particularly to an uncooperative target.

OBJECTIVES & OUTCOMES

- The project has held four TIMs to develop the requirements and systems design of the sled, in cooperation with its development partners
- The principle deliverable for the project is an operational sled, built in JSC B348, ready for air bearing testing beginning in FY13.

INFUSION POTENTIAL

- The testing performed through this project will potentially revolutionize the state of the art regarding Prox Ops sensors. Reducing the cost, weight and complexity of operational remote sensors will allow a fielded system to be operated much more cost effectively and with greater potential for commercialization.

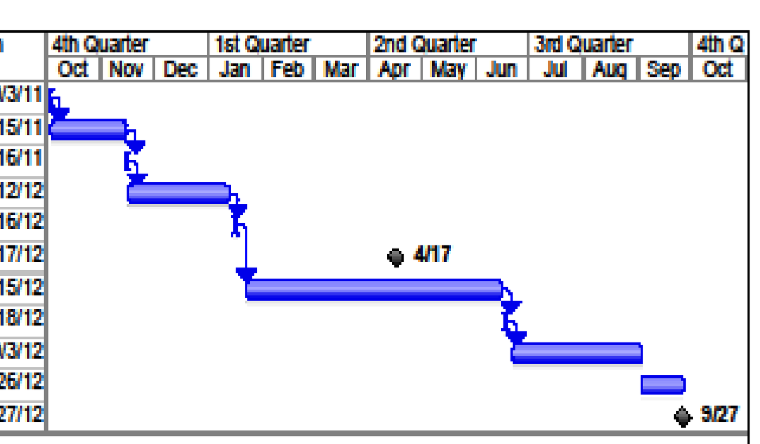


NASA TECHNOLOGY AREA ROADMAP

- Orbital debris is a major concern for national security and in-space mission infrastructure. An operational system requires advances in sensor systems, **(TA 4.0.0 and 5.0.0)**, as well as advancing modeling and processing **(TA 11.0.0).** JSC Topic and Subtopic(s) Technology Addressed**: #3 (3.10)** and **#1 (1.4)**
- By developing ADR technology, JSC will advance the ability for **automatic change detection via imagery** and greatly **reduce the mass** needed for the sensor systems.

PROJECT DEVELOPMENT SCHEDULE

ID	Task Name	Duration	Start	Finish
1	Kick-off	1 day	Mon 10/3/11	Mon 10/3/11
2	Requirements Development	32 days	Tue 10/4/11	Tue 11/15/11
3	TIM 1 @ JSC(B 348)	1 day	Wed 11/16/11	Wed 11/16/11
4	Sensor Design	41 days	Thu 11/17/11	Thu 1/12/12
5	TIM2 @ JSC (B 348)	1 day	Mon 1/16/12	Mon 1/16/12
6	TCSR#1	0 days	Tue 4/17/12	Tue 4/17/12
7	Brassboard Sensor Development	105 days	Mon 1/23/12	Fri 6/15/12
8	TIM3 @ JSC (B 348)	1 day	Mon 6/18/12	Mon 6/18/12
9	Brassboard Sensor Testing	52 days	Fri 6/22/12	Mon 9/3/12
10	Final Report Generation	18 days	Mon 9/3/12	Wed 9/26/12
11	Final TCSR	0 days	Thu 9/27/12	Thu 9/27/12



Project Start TRL (1-9): 3
Current TRL (1-9): 4

Spacesuit Evaporator-Absorber-Radiator (SEAR)

PROJECT MANAGEMENT

Grant Bue/JSC/EC 281.483.5271 grant.c.bue@nasa.gov

Scott Cupples/JSC/XA 281.483.1125 j.s.cupples@nasa.gov

Ed Hodgson/HSWL 860.660.2888 ed.hodgson@hs.utc.com

Mike Izenson/Creare 603.640.2405 mgi@creare.com

Weibo Chen/Creare 603.640.2425 wbc@creare.com

PROJECT OVERVIEW

This project combines two proven technologies, Spacesuit Water Membrane Evaporator (SWME) and Lithium Chloride Absorber Radiator (LCAR), into a non-venting system for thermal control. The venting and valving between the technologies was tested in relevant thermal vacuum conditions. A thermal fluid model is being built and correlated to the test data. This model would be used to support a conceptual design of a full scale system for an ISS DTO demonstration. This one of two follow-on projects to FY '11 ICA Sustainability Call: "Liquid Desiccants for Environmental Control."

RELEVANCE/ VALUE TO NASA

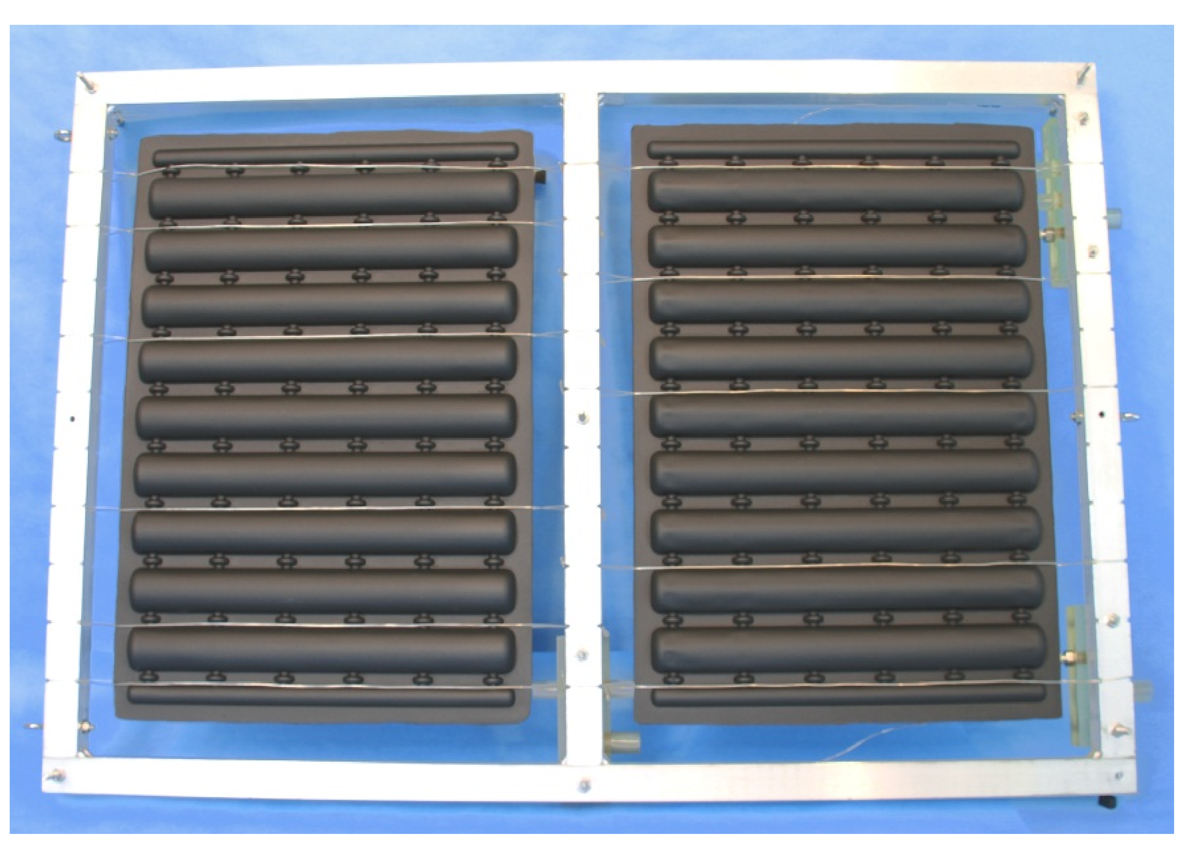
For decades NASA JSC has sought a practical method for regenerable, robust non-venting heat rejection: SEAR promises to be such a system

OBJECTIVES & OUTCOMES

- Built 1/5 scale radiator,1/3 scale absorber and combined with SWME
- Achieved integrated SEAR operation rejecting EVA heat loads with minimal loss of water in relevant thermal vacuum environments
- Achieved sustained operation with high radiator temperatures and low cooling loop temperatures required for human thermal comfort
- Performance capability is compatible with anticipated system environments, heat loads, and surface area available for radiator integration
- Realized significant opportunity for further optimization of design and performance
- Using model to design a full-scale SEAR system suitable for an ISS DTO

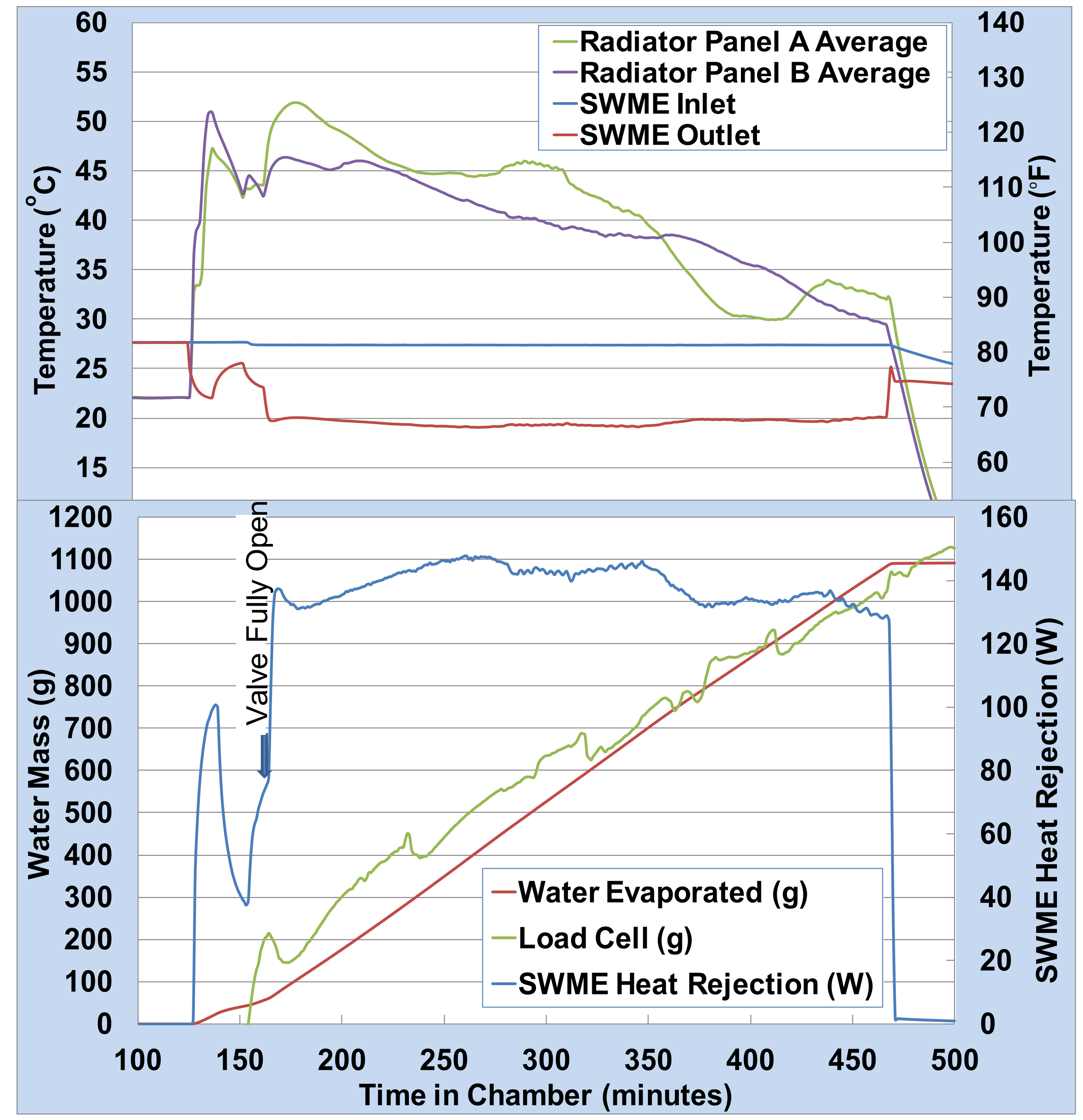
INFUSION POTENTIAL

The final ISS DTO product points to future proposals for advancing technology to TRL7. The ISS program would serve as a science platform for the technology while benefiting from reduced consumable use. Technology could then be incorporated multifunctionally into the Advanced Portable Life Support System (PLSS) housing.



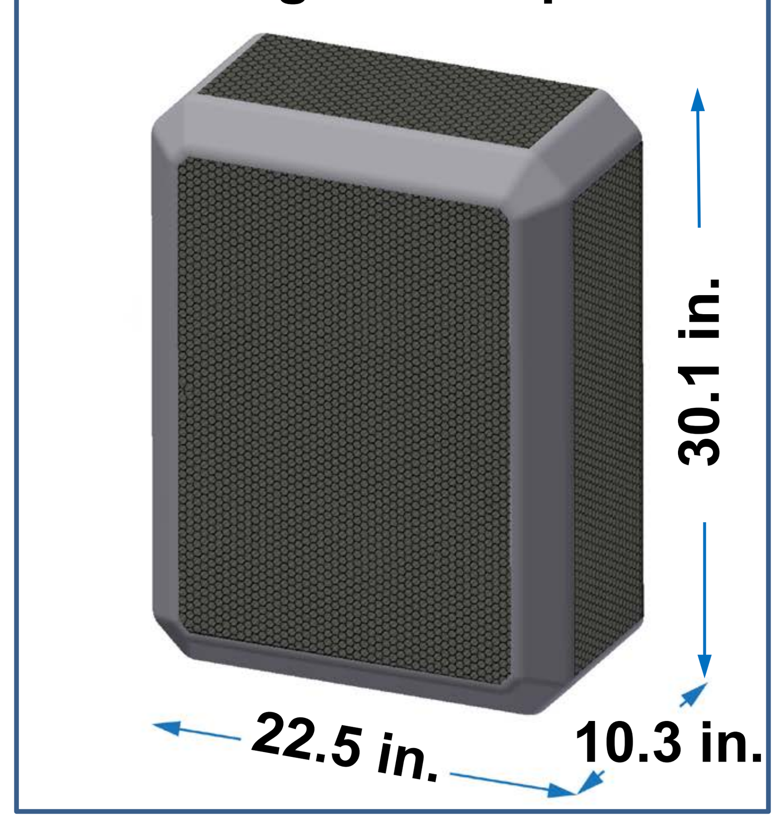
LCAR Test Article

LCAR in Thermal Vacuum Chamber



SEAR Performance in Chamber N

DTO concept incorporates absorption radiator into a 5-panel honeycomb composite structure in the Advanced PLSS housing. This multifunctional approach provides at least 500W radiation and protects the PLSS components with minimal impact on PLSS and Suit Port design envelopes.



NASA TECHNOLOGY AREA ROADMAP

❑ **NASA OCT Grand Challenge Addressed: Space Colonization**

This non-venting system directly addresses the need for "..effective close-loop systems ..."

❑ **NASA Technology Area Roadmap Addressed: Human Health , Life Support and Habitat ion Systems** *As an EVA thermal acquisition/rejection system this technology meets the need for "crewed missions venturing beyond LEO will require technologies for high reliability, reduced mass, self-sufficiency, and minimal logistical needs... "*

PROJECT DEVELOPMENT SCHEDULE

O N D J F M A M J J A S

Milestones: Creare Phase III (F); Form 90 (M); HS GSA (A)

- Procurement
- Test Build-up
- Midterm-Report (Apr 17)
- Chamber N TherVacTest
- Analysis and Correlation
- DTO Design, Modeling
- Final Report (Sep 27)

Project Start TRL (1-9): 2

Current TRL (1-9): 4

In-space Manufacturing & Repair

PROJECT MANAGEMENT

PM: Michael Waid, ES7, 281-483-1257, michael.c.waid@nasa.gov
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JSC Collaborators: EG, ER, EV, EP, KX, NT, DX

PROJECT OVERVIEW

- Develop and Demonstrate Concept of Operations for In-space Manufacturing & Repair
- Electron Beam Technology for In-space Repair, Joining, and/or Fabrication of Near-Net-Shape Parts
- Integrate using JSC Integrated Power, Avionics, & Software (iPAS) and Dextrous Manipulator Testbed (DMT) Labs

RELEVANCE/ VALUE TO NASA

- Structural Repair of ISS Micrometeoroid Orbital Debris (MMOD) Damage
- Sparing & Contingency Parts on Exploration Missions.

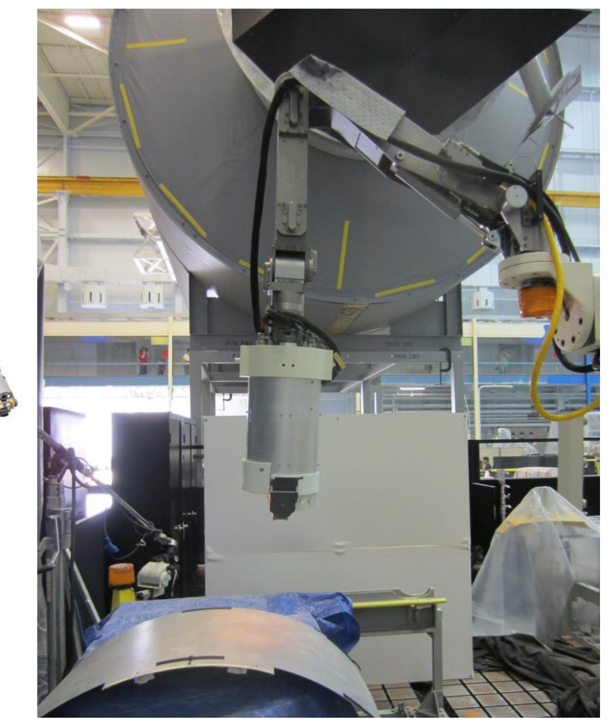
OBJECTIVES & OUTCOMES

- ISS Repair ConOps, including iGOAL Graphics Simulation
- Remote Electron Beam Manufacturing/Repair iPAS Demo
- DMT Robotics Testing Using Rapid Prototyped E-beam Gun
- Ground Demo of ISS MMOD Damage Repair
- Ground E-beam Material Property Statistical Testing

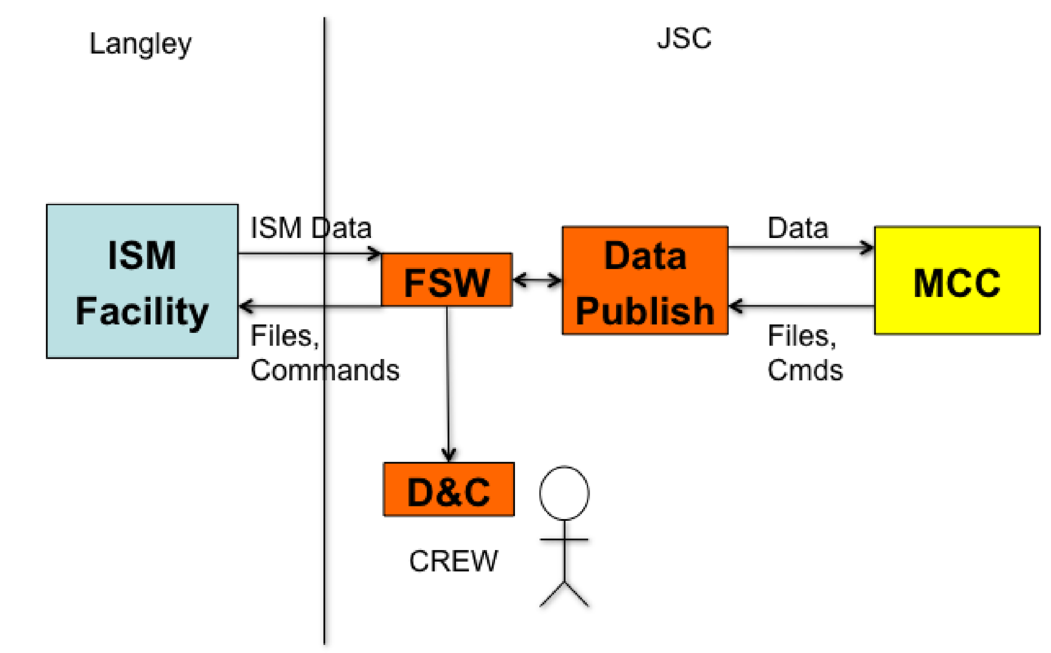
INFUSION POTENTIAL

- ISS Repair: Mitigate ISS Risk #4669 for Pressurized Module Leaks with E-Beam Repair System
- Advanced Exploration Systems: Supportability for Deep Space Habitat and/or Waypoint Missions

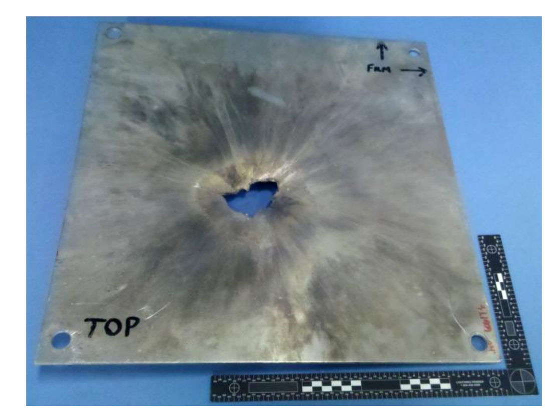
SPDM



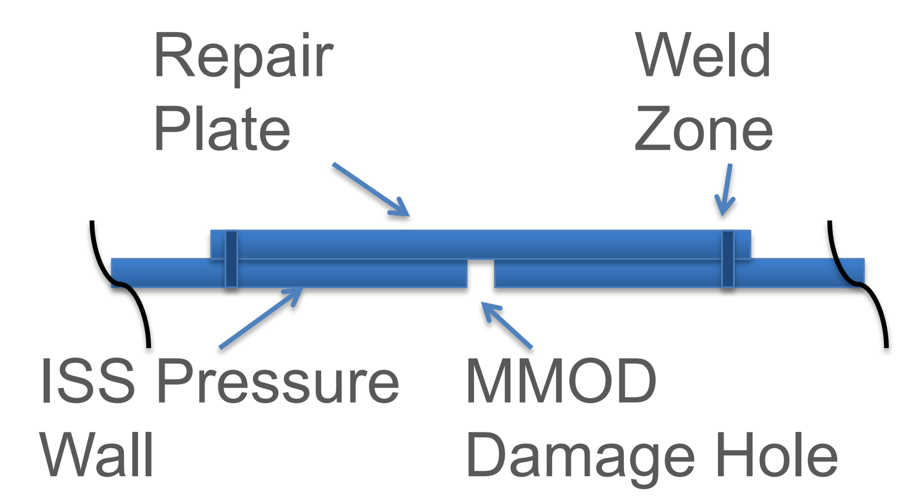
DMT Testing



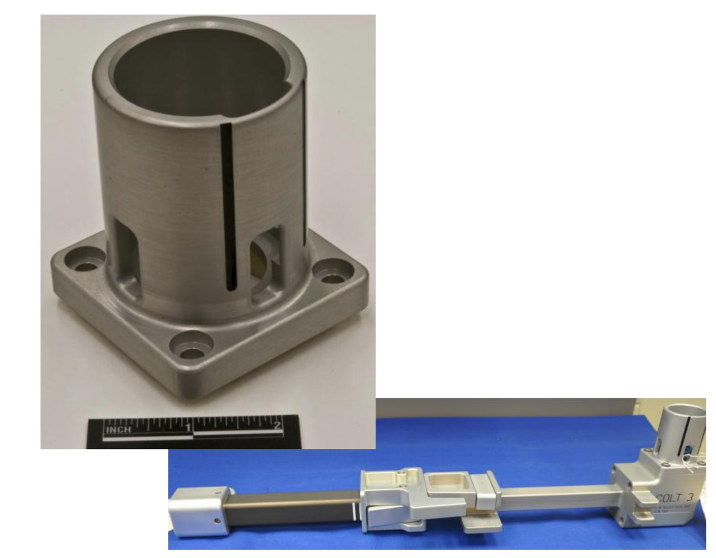
iPAS Remote Demo Concept



MMOD Test Panel



E-beam Structural Repair

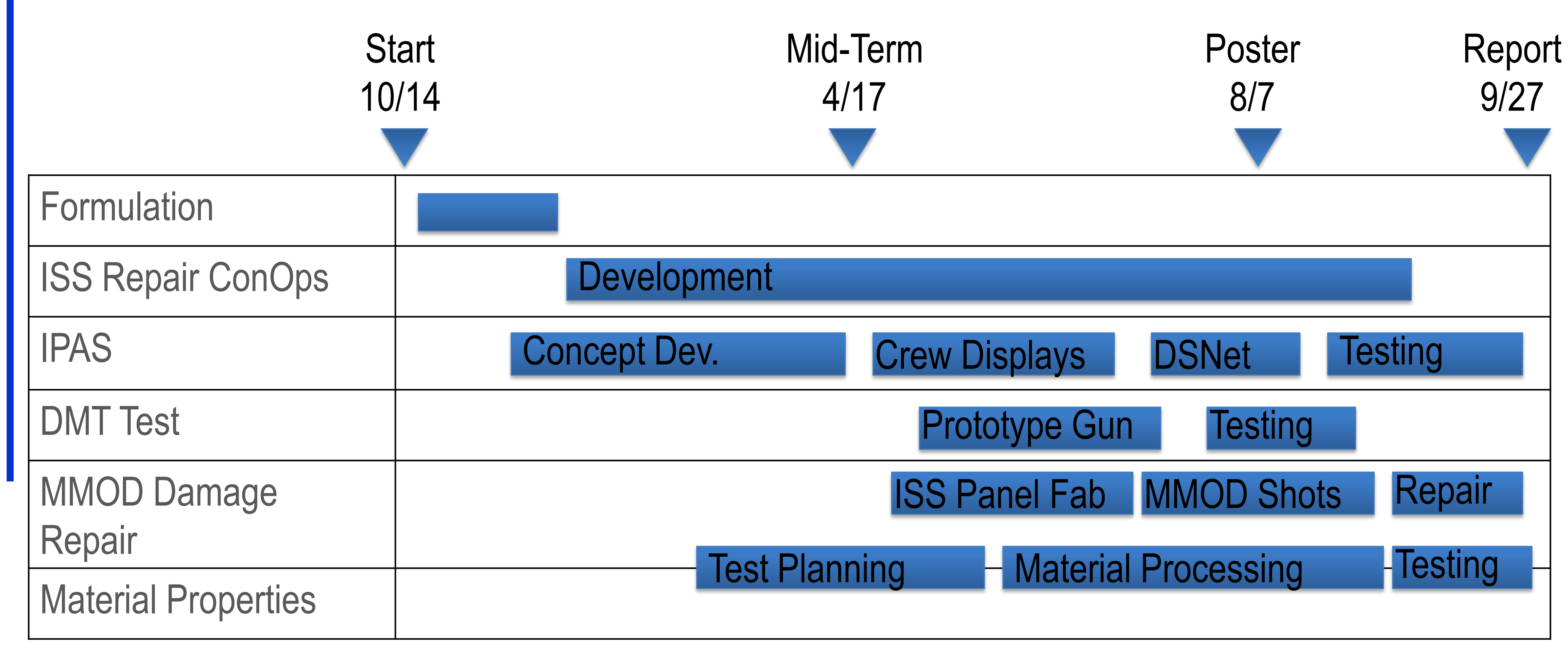


Flight-like “Receptacle” Part from E-beam Preform

NASA TECHNOLOGY AREA ROADMAP

•TA12 2.4.1 Manufacturing Processes: In-space Assembly, Fabrication, and Repair

PROJECT DEVELOPMENT SCHEDULE



Project Start TRL (1-9): 2-3
Current TRL (1-9): 3-4

Wide-Spectrum Organic Analysis Instrument

PROJECT MANAGEMENT

Scott Messenger, KR/ARES & Simon Clemett ESCG/ARES 4-2786; scott.r.messenger@nasa.gov; simon.j.clemett@nasa.gov; Collaborators: Laura Labuda (EC), Stan Love (CB), John James (SF)

PROJECT OVERVIEW

- *We designed and constructed a unique laser organic mass spectrometer to organic species with great sensitivity on micrometer spatial scales. The instrument can be used to analyze mixtures of molecules in complex materials without extraction, purification, or other complex sample preparation. With our collaborators at JSC, we will use the instrument in a wide range of applications, beginning with analysis of ISS waste water samples and toxicology studies of asteroidal and lunar dust.*

• RELEVANCE/ VALUE TO NASA

- This is a unique instrument with unprecedented analytical capabilities – it will help to maintain the technical and scientific leadership of JSC and NASA and will add value to past, present and future missions.

OBJECTIVES & OUTCOMES

- *In FY1 we constructed a Xe-tripling cell that efficiently produces VUV photons. This year we incorporated the VUV source into a two-step laser organic mass spectrometer.*
- *The resulting instrument measures a wide range of organic molecules with an unprecedented combination of sensitivity and spatial resolution.*

INFUSION POTENTIAL

- *We have begun using the instrument in funded research and we will soon begin analysis of NASA mission samples and a wide range of samples from JSC collaborators. The technology is being considered for a patent and may have commercial potential.*

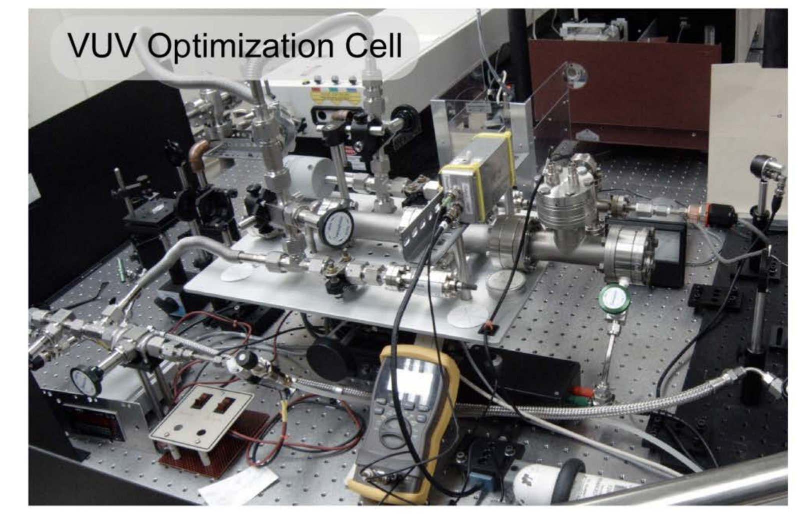
Top L) The Xe tripling cell undergoing testing

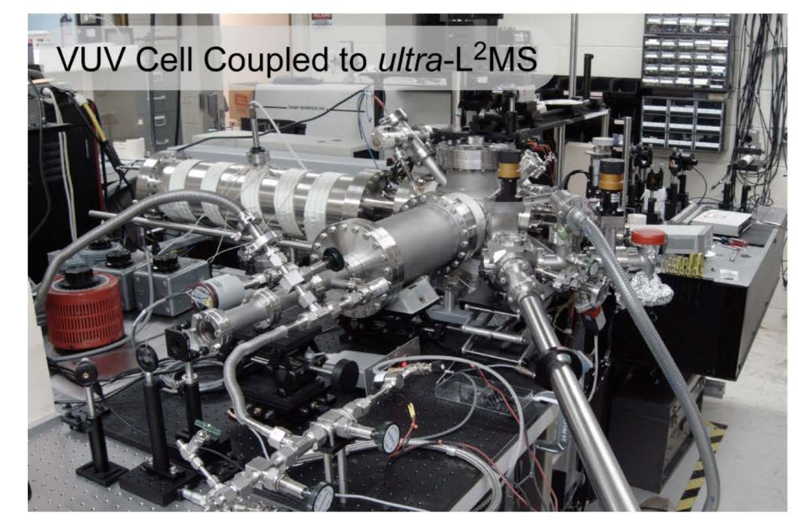
Center L) VUV cell coupled to mass spectrometer

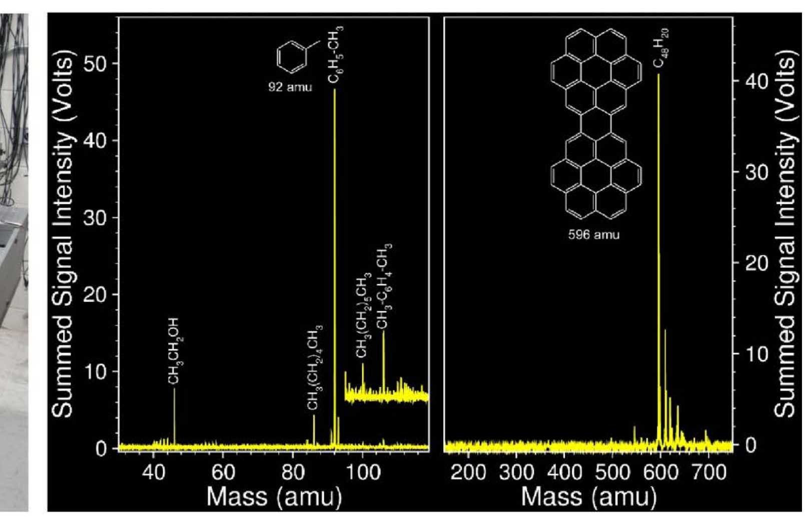
Center R) First mass spectra obtained by VUV ionization

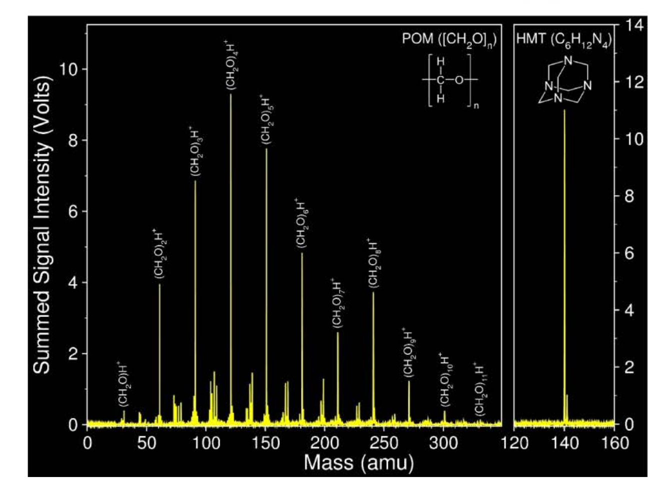
Bottom L) Polymer test materials measured by two-step VUV laser mass spectrometry

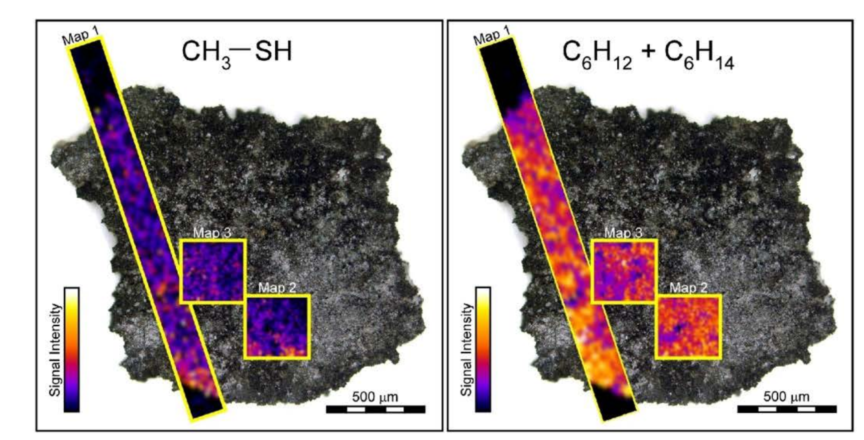
Bottom R) Spatial maps of organic compounds measured in an ancient meteorite with 10 micrometer spatial resolution







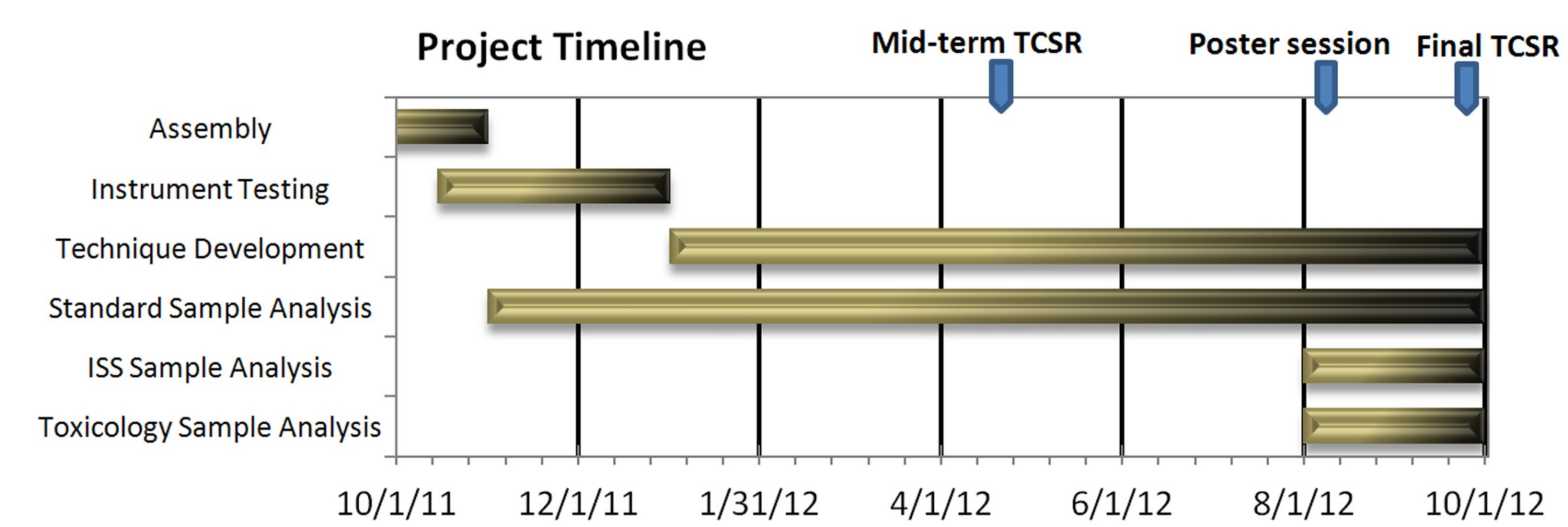




NASA TECHNOLOGY AREA ROADMAP

•<u>TA08/Science Instruments, Observatories, & Sensor Systems: In situ instruments</u> Microscopic organic analysis directly supports planetary science missions, including sample return missions Stardust, Genesis, OSIRIS-REx, and future lunar and Mars sample return missions.

PROJECT DEVELOPMENT SCHEDULE



Project Start TRL (1-9): <u>5</u>

Current TRL (1-9): <u>7</u>

Brine Recovery in Containment (BRIC)

PROJECT MANAGEMENT

Karen Pickering, Ph.D. / EC3. and Torin McCoy/SF2.
281-483-2688, karen.d.pickering@nasa.gov

PROJECT OVERVIEW

- The Brine Residual in Containment (BRIC) project aims to close the water recovery loop by enabling water to be extracted from concentrated wastewater brines. BRIC is based on an in-place drying concept within a sealed disposal container. The design is intended to accommodate the three phases of brine processing, liquid, gas and solid, while reducing the potential for system fouling and exposure of crew to toxic and hazardous brine material. BRIC is described in technology disclosure MSC-24964-1, which will be published in an upcoming issue of NASA Tech Briefs.

RELEVANCE/ VALUE TO NASA

- The NASA OCT Grand Challenge addressed is to Expand human presence in space. The NASA Technology Area Roadmap Addressed is TA06 / Human Health and Habitation Systems, Environmental control and Life Support System.

OBJECTIVES & OUTCOMES

- Characterize physical properties of brines.
- Develop microgravity-compatible evaporator design.

INFUSION POTENTIAL

- The technology will be infused into a system-level environmental control and life support system, support deep-space habitats or other exploration missions. The system will be demonstrated through integrated testing conducted by the AES program.

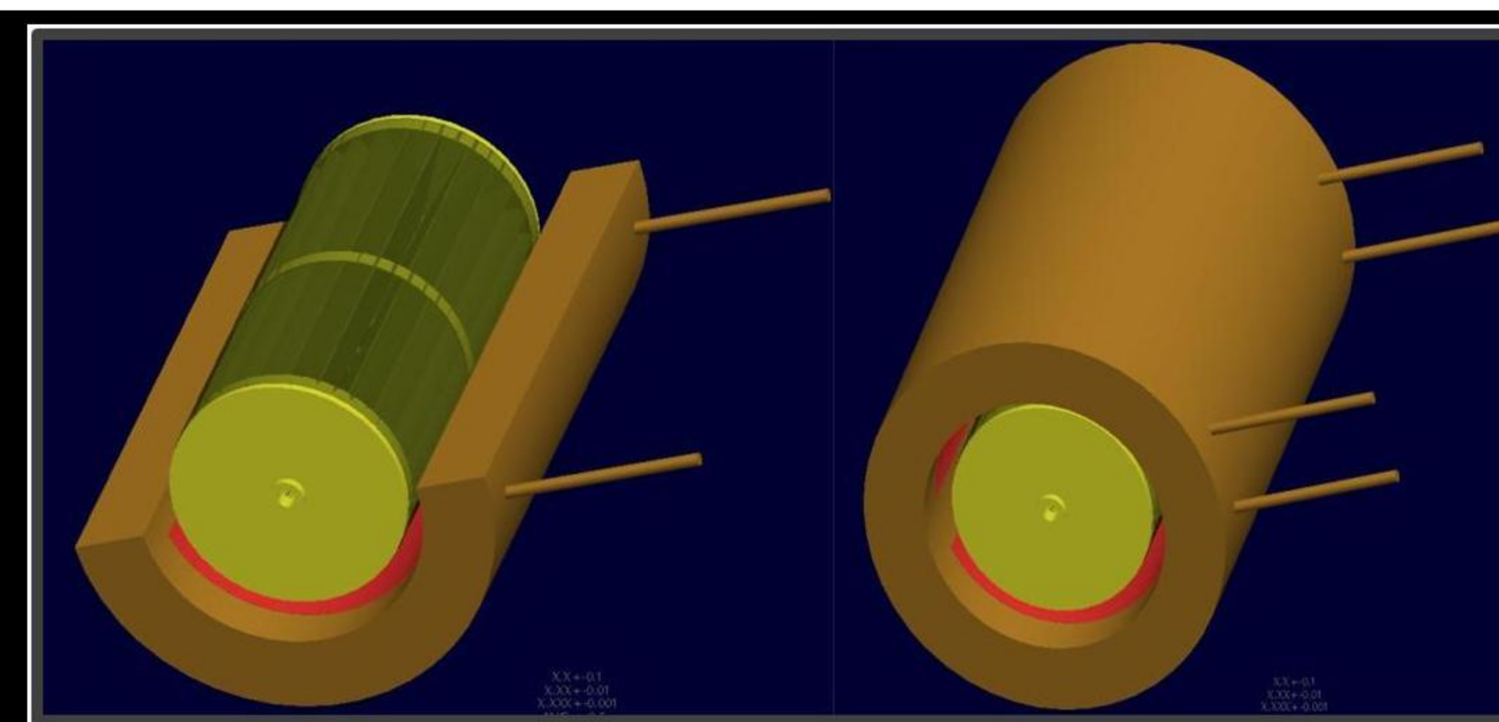


Figure 1. Preliminary CAD Model of BRIC evaporator assembly showing microgravity compatible solids drying and collection container (yellow), Demister element (green), IR heat source (brown/red).

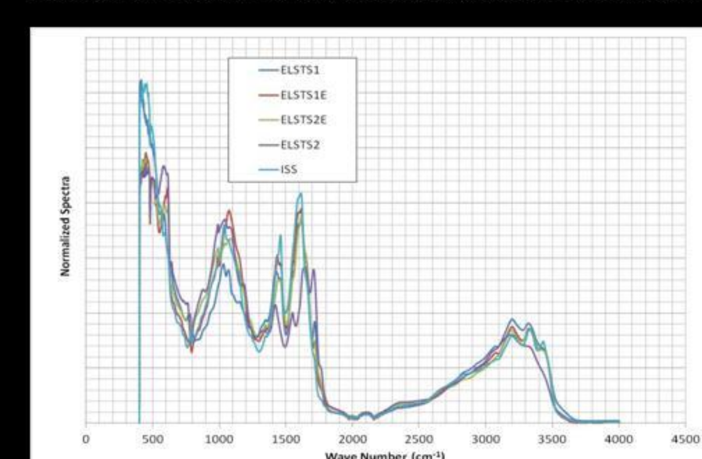


Figure 2. FTIR spectrum of a dehydrated on analogue spacecraft brines

Figure 3. Surface Contact Angle Estimates Brine on Polypropylene

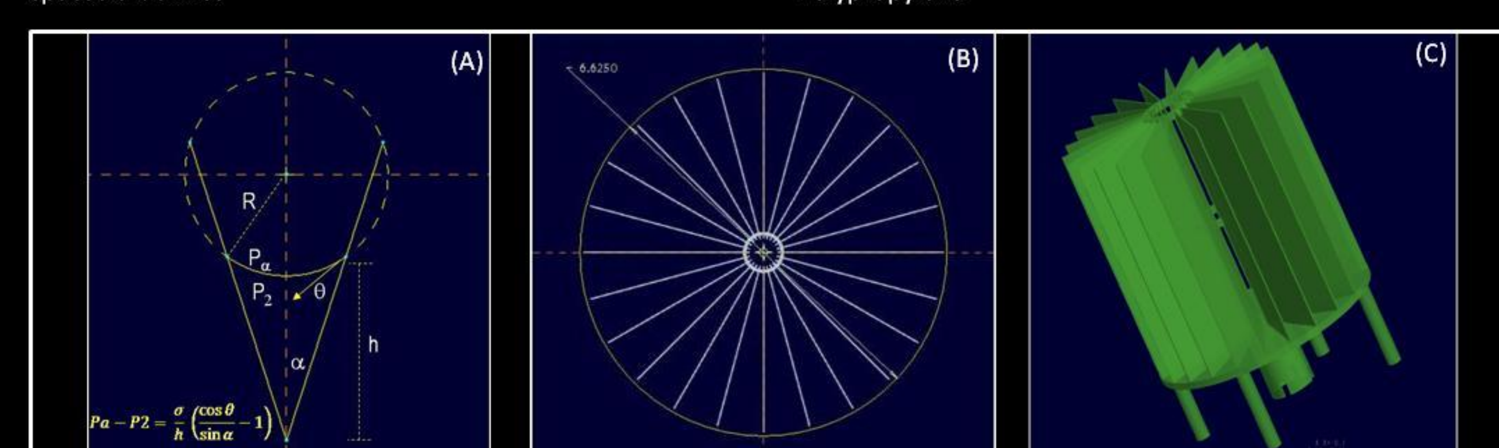
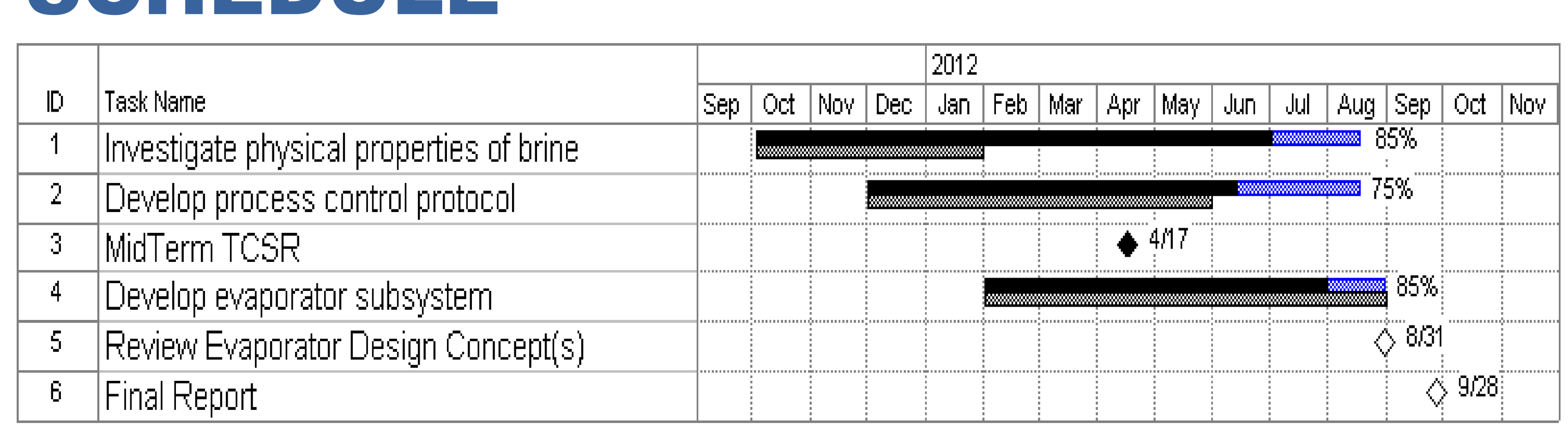


Figure 4. Capillary force equations for "liquid in a wedge" (A), Concept evaporator cross-section, 24 vanes with 15° interior corner angles (B), Sub-Scale drop tower test part (C).

NASA TECHNOLOGY AREA ROADMAP

- Increasing the overall water recovery percentage is identified as a major challenge on Technology Roadmap TA06, WBS 2.1, with a goal of 98% water recovery by 2015. **Goal *cannot be achieved without brine water recovery.***

PROJECT DEVELOPMENT SCHEDULE



- **Milestones**: Mid-term TCSR, 4/17/12; Review Evaporator Design, 8/30/12; Final TCSR 9/27/12.

Project Start TRL (1-9): 2
Current TRL (1-9): 2

Hybrid Li-ion Supercapacitor / Li-ion Battery System for Extended Performance

Dr. Judith Jeevarajan, EP5, D.R. Pratt, EP5, J. Graika, EP5, M. Martinez, EP5 and Daniel Harrison, ER4

judith.a.jeevarajan@nasa.gov; 281-483-4528

PROJECT OVERVIEW

- The lithium-ion supercapacitors with a working voltage of 3.8 V to 2.5 V (can charge up to 4.2 V) can be efficiently used to charge li-ion batteries on an as-needed basis.
- The li-ion supercapacitors can be store charge from various sources (solar, wind, water) for long periods. The li-ion battery can be reduced to half the capacity (required for nominal EVA) and designed to allow charging of one battery by the supercaps while the other is providing power (to Rover, Suit or other terrestrial applications).

RELEVANCE/ VALUE TO NASA

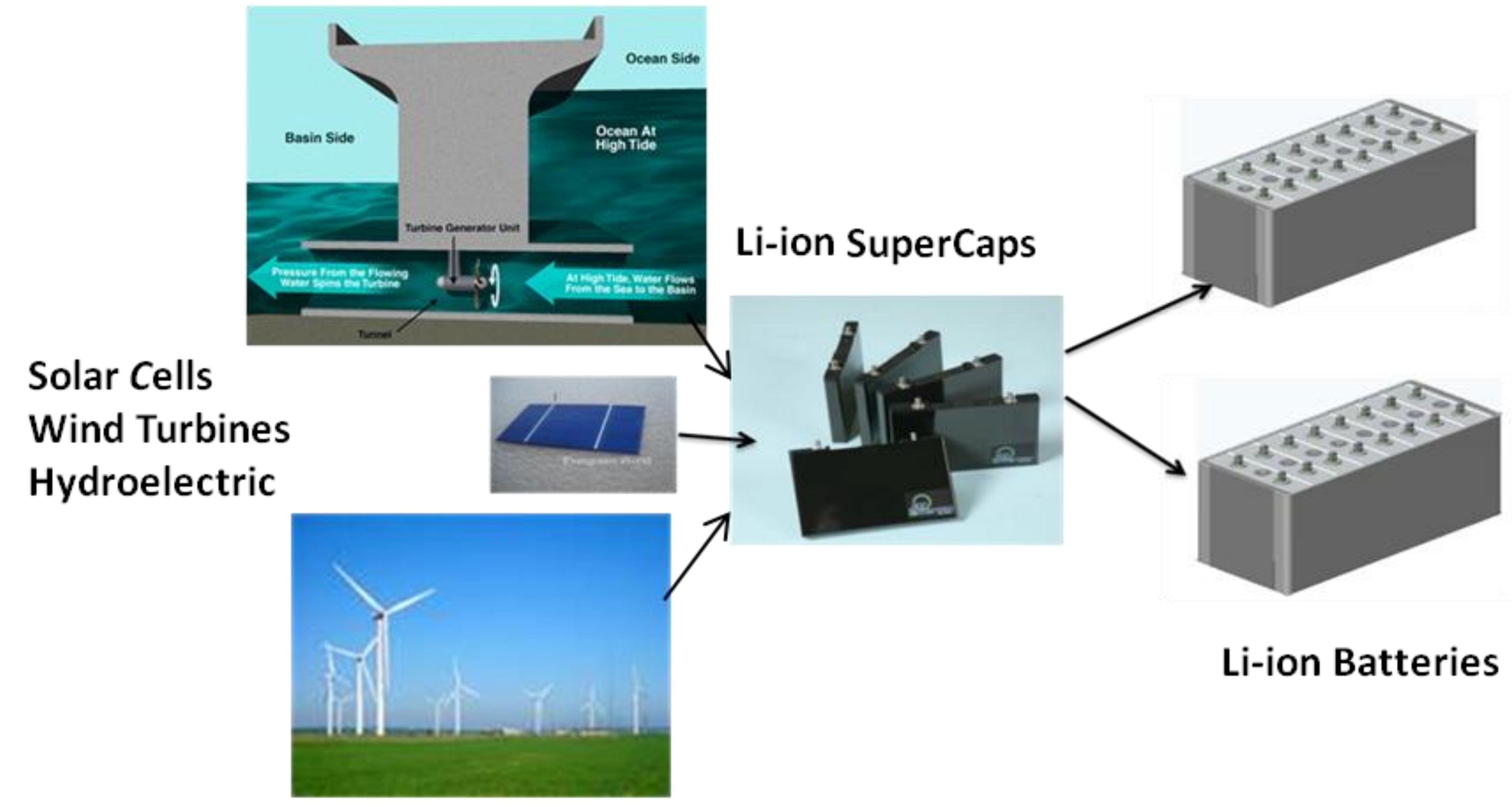
- The use of the supercaps to safely charge batteries extends the period of performance required from a battery while reducing the battery size by half.

OBJECTIVES & OUTCOMES

- Completed supercapacitor performance and safety test.
- Developing and testing supercapacitor /battery modules.

INFUSION POTENTIAL

- The design can be used to reduce the size of the batteries used in the Advanced EVA suit for future NASA space missions. Collaboration has been established with the Robotics and EVA Suit team for technology infusion.
- This can be extended to grid applications (wind energy and energy regeneration/harvesting) as well as to store energy from other sources such as tide (hydroelectric).



NASA TECHNOLOGY AREA ROADMAP

(TA 2 / TA 3 / TA 4) Ultra-high energy density power systems

- The energy challenge is to obtain a power system that runs longer , supports high demands and weighs less (<5 kg). This system will provide ultra-high energy density and longer runtime to safely meet the needs of the future EVA missions.

PROJECT DEVELOPMENT SCHEDULE

Task	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sep
Project start	■											
Procure Li-ion Capacitors and test		■	■	■	■	■	■	■				
Circuit board design, supercap module buildup, battery / supercap design buildup								■	■	■	■	
Mid-Term TCSR								■				
Test to optimize runtime at IDC											■	
Field Demo and/or demo in the IDC											■	■
Final system design reporting to EVA and ER and Center IRD Panel												■

Project Start TRL : 2

Current TRL : 4

A Ground Testbed to Advance US Capability in Autonomous Rendezvous and Docking

PROJECT MANAGEMENT

Christopher D'Souza, EG6

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PROJECT OVERVIEW

- This project will develop the capability to field an AR&D system which can be applied to any mission needing to rendezvous and dock with another vehicle. A ground test-bed comprising algorithms, flight software implemented and tested in a target flight processor and validated with scenarios and missions of interest to NASA has been developed.

RELEVANCE/ VALUE TO NASA

- The US does not have a mature Autonomous Rendezvous and Docking (AR&D) capability, falling behind even our allies in this area; yet it is a cornerstone in any human spaceflight roadmap as we take on the mantle of active debris removal and venture beyond LEO. This effort seeks to remedy this for the Agency.

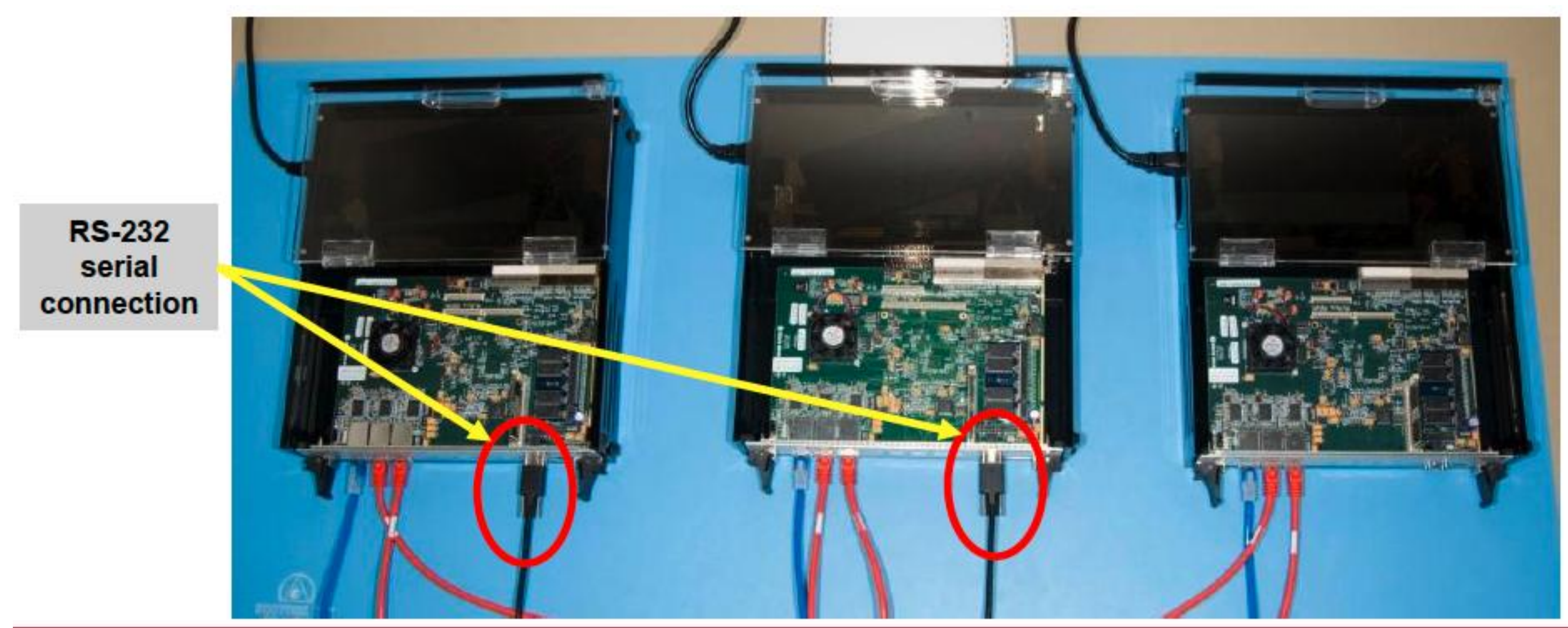
OBJECTIVES & OUTCOMES

- Implemented AR&D Algorithms and Software on a Target Flight Processor (WR SBC750GX running vxWorks ARINV 653)
- Goal: AR&D Software Integrated into iPAS

INFUSION POTENTIAL

- *This project will develop a standardized US capability to provide an 80% solution for any future AR&D mission; the remaining 20% will have to be tailored to suit unique mission needs and constraints. The AR&D FSW will be ready for incorporation into any NASA AR&D mission, whether human or robotic, cooperative or un-cooperative, LEO, GEO, NEO, or deep-space.*

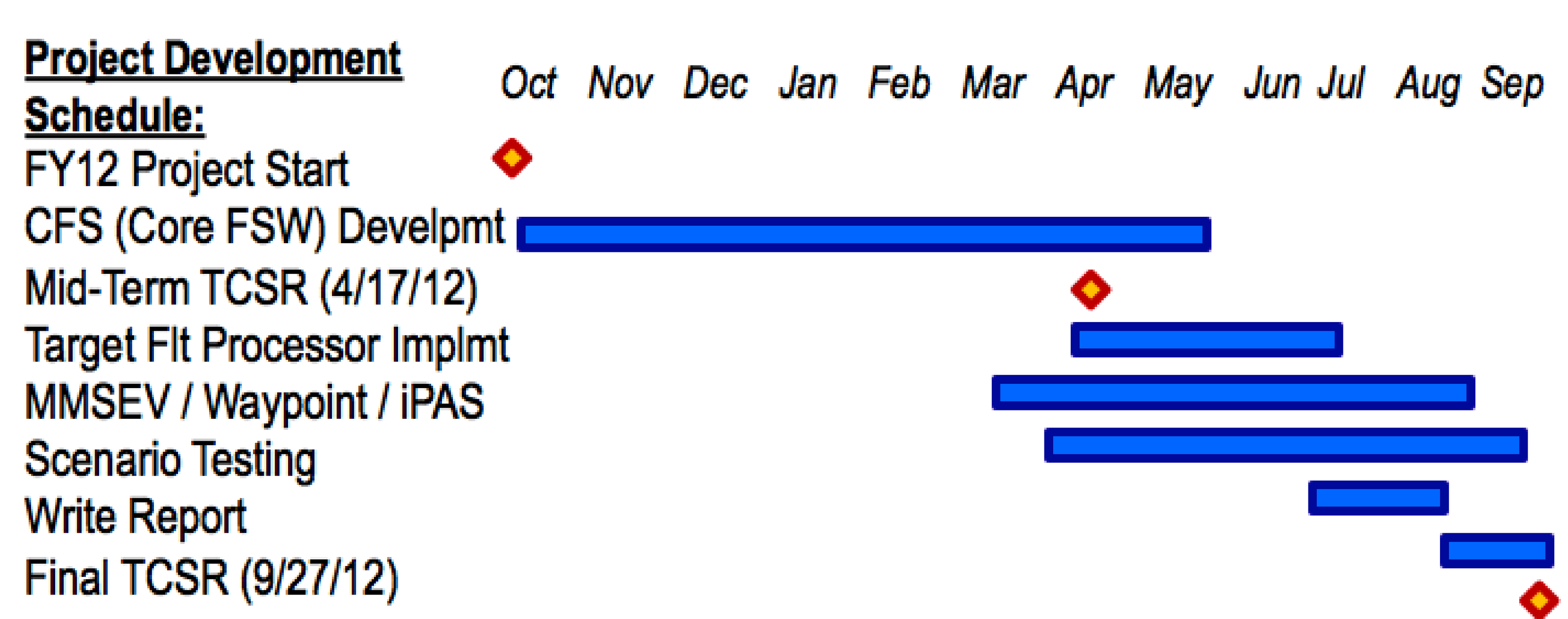
Wind River (WR) SBC750GX board running vxWorks ARINC 653 platform



NASA TECHNOLOGY AREA ROADMAP

- *Project will develop both algorithms (Robotics, Tele-Robotics and Autonomous Systems), incorporate sensors (Communications and Navigation) and simulation software (Modeling, Simulation, Information Technology and Processing) to support development and testing of autonomous rendezvous and docking capability.* (WBSL 4.0.0, 5.0.0, 11.0.0)

PROJECT DEVELOPMENT SCHEDULE



Project Start TRL (1-9): 4

Current TRL (1-9): 5

Active Radiation Shielding Study

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Dan Fry, Ph.D., Science PI – SF2/Environmental Factors (281.483.2281, dan.j.fry@nasa.gov)

Scott Winter, Collaborator – NC2/SE&I (281.483.6855, d.s.winter@nasa.gov)

PROJECT OVERVIEW

- The deep space radiation environment is energetic and presents great risk to astronauts. Passive shielding becomes massive for long duration deep space missions. This study assesses the applicability of magnetic shielding to protect against exposure from Solar Proton Events (SPEs).

RELEVANCE/ VALUE TO NASA

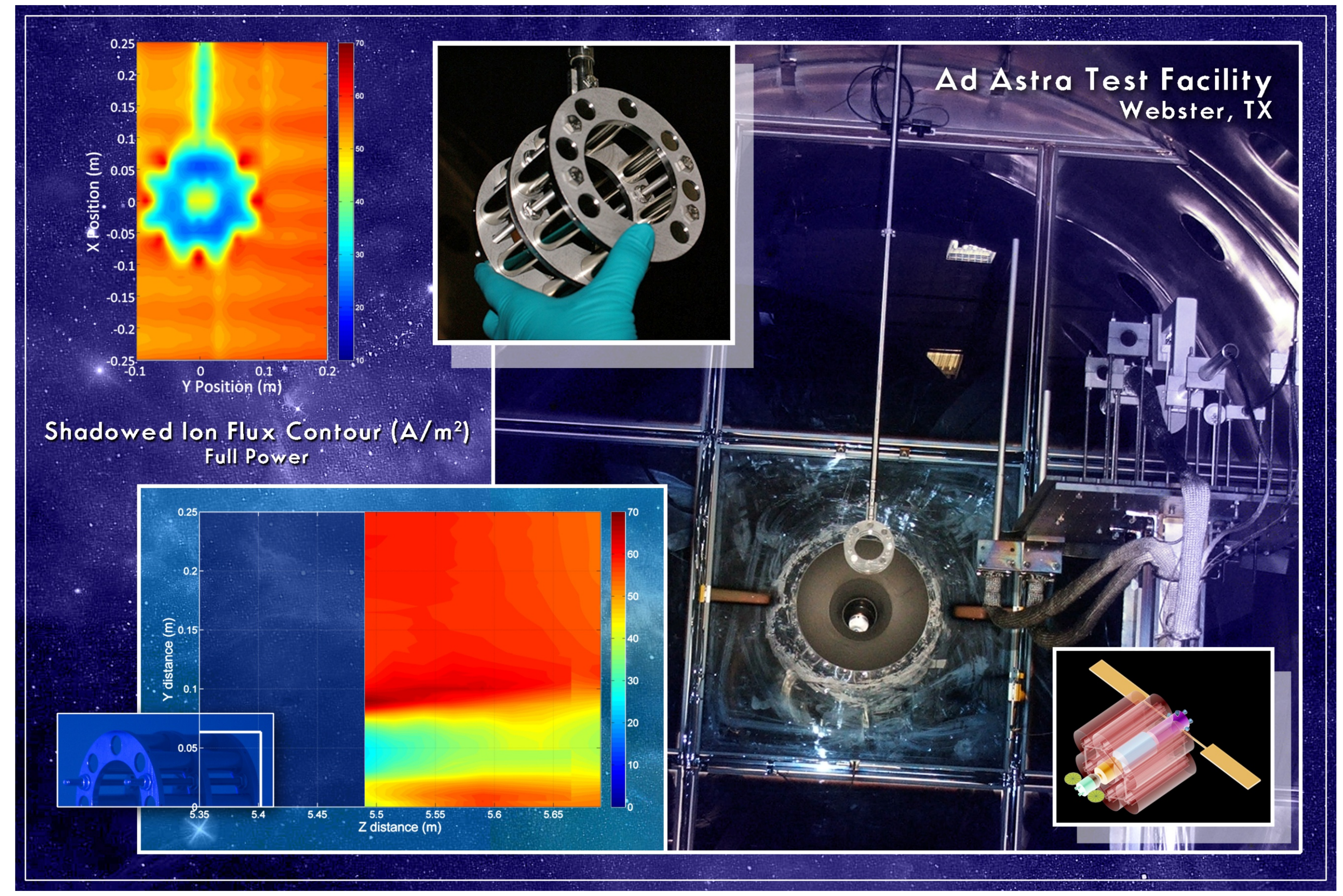
- Radiation shielding is a technical challenge that needs to be addressed to enable human exploration of space.

OBJECTIVES & OUTCOMES

- Plasma sheathing tests performed while leveraging recent results from Rutherford Appleton Lab research.
- Synchrotron radiation effects from particle momentum change also analyzed. Data review and analysis complete.
- Deliverable will be in the form of a final report.

INFUSION POTENTIAL

- Future studies might consider mass, power, scalability, and additional architectural concepts for a space habitat.
- High Temperature Superconductors (HTS) may be used to generate the protective magnetic space shield. HTS have multiple applications currently being developed in the energy sector.



NASA TECHNOLOGY AREA ROADMAP (level 2)

- TA06: Human Health, Life Support & Habitation Systems - Radiation
- TA07: Human Exploration Destination Systems - Mission Operations & Safety

PROJECT DEVELOPMENT SCHEDULE

(Oct 2011 – Sept 2012)

Studies Development Schedule	May	June	July	August	Sept
IR&D					9/27/12
TCSR	5/12	✓			
MIT Analysis		6/12 ✓			
Test Data Review			7/12 ✓		
Architecture - CAD work		8/12			
Final Report					9/12 *

Project Start TRL (1-9): 1

Current TRL (1-9): 1

Miniature Exercise Device (MED)

PROJECT MANAGEMENT

Project Leader: JSC/ER3/Cherice Moore; 281-483-8780; cherice.moore-1@nasa.gov

Collaborators: JSC/SK2/Linda Loerch; 281-483-2557; linda.loerch-1@nasa.gov
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JSC/ER3/Javier Lucero; 281-244-5979; javier.lucero-1@nasa.gov

PROJECT OVERVIEW

As we travel beyond low earth orbit, smaller, lighter, highly effective exercise devices to aid in maintaining crew health will be required. The MED demonstrates compact, motion-system technology required to reduce the volume and weight of resistive exercise equipment.

RELEVANCE/ VALUE TO NASA

Every extended duration space mission with people will require high-performing exercise equipment to prevent physiological degradation. To provide these capabilities often requires considerable mass and volume. The current ISS resistive exercise of >1,200 lbs. will need to be reduced while maintaining current performance. MED provides high loading (expected to be >280 lbs./unit) with small mass & volume. Two MED units could provide an ISS ARED-equivalent loading capability.

OBJECTIVES & OUTCOMES

Project objective planned to prepare a functional prototype.

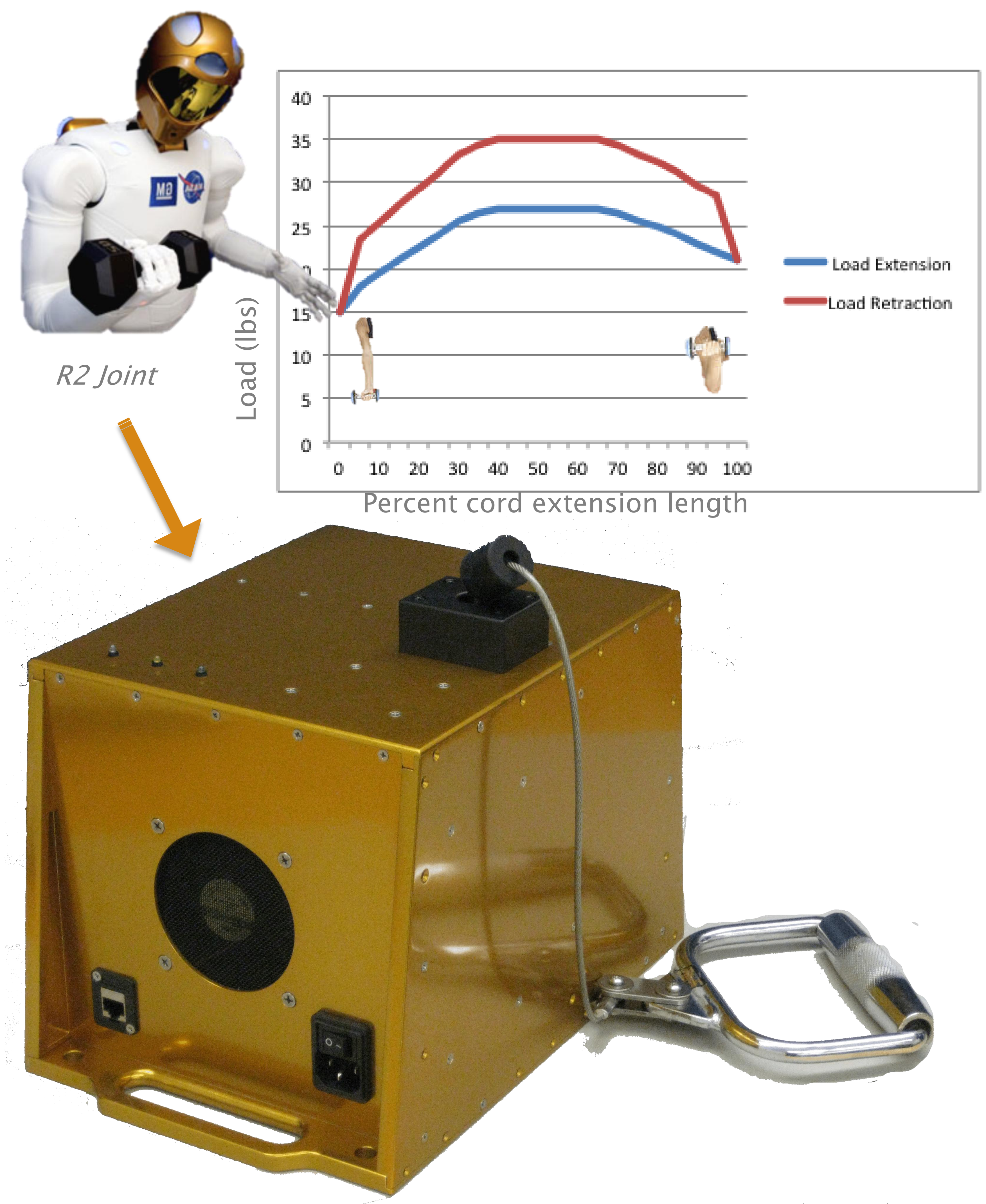
Outcomes:

- Accomplished the MED Mechanical & Electrical design, development, and fabrication.
- Completed the MED Software design.
- Worked with SK to start assessing variable load curves to use with MED.

INFUSION POTENTIAL

Once the prototype is proven, several infusion options are available:

- To integrate MED during ARED exercise to off-set loads from the shoulders & lower back to the lower body
- To fly an SDTO MED for performance assessment for resistive exercise on ISS via ISTAR (From the ISS evaluation, further design refinement for exploration would be prepared.)
- To create a compact, commercially-sponsored and viable exercise unit



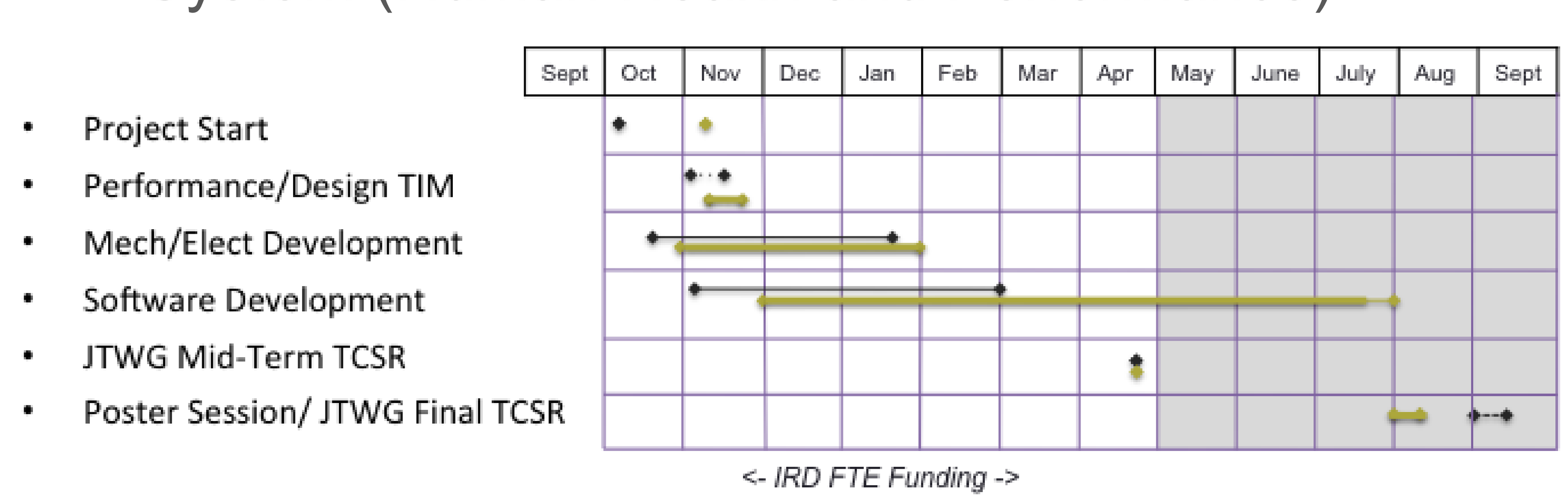
Prototype Miniature Exercise Device (MED)

DESCRIPTION

The Robonaut and ARED derived MED not only is small (approximately 20 pounds and less than 1 ft^3), but will also provides new exercise technology through the ability to vary the eccentric and concentric loading throughout the cord displacement cycle to optimize muscle strength building.

NASA TECHNOLOGY AREA ROADMAP

- TA06.3/Human Health, Life Support & Habitation System (Human Health and Performance)



Project Start TRL (1-9): 3
Current TRL (1-9): 5

Multi-Phase Methane Heat Xfer

PROJECT MANAGEMENT

J.C. Melcher, Ph.D. / JSC-EP4, J. Bruggemann / WSTF-RD, Prof. A. Choudhuri / Univ. Texas @ El Paso
(281) 244-6427, john.c.melcher@nasa.gov, (575) 525-7659, jeremy.bruggemann@nasa.gov

PROJECT OVERVIEW

•Conduct laboratory scale study of regeneratively cooled rocket engine heat transfer using methane. Measure fluid and wall temperatures through multiple states and phase changes. Regen engine analytic model generated and validated with data. Innovative approach for sub-critical methane boiling heat transfer.

RELEVANCE/ VALUE TO NASA

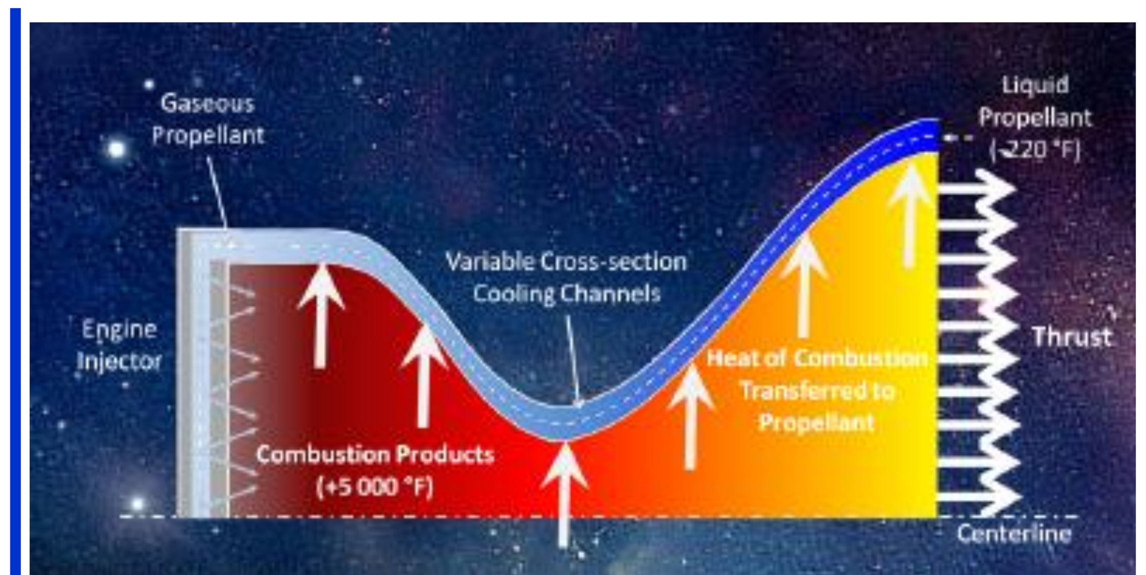
- Heat transfer experiments advance the fundamental understanding of two-phase methane, which enable high-performance "green propellant" rocket engines

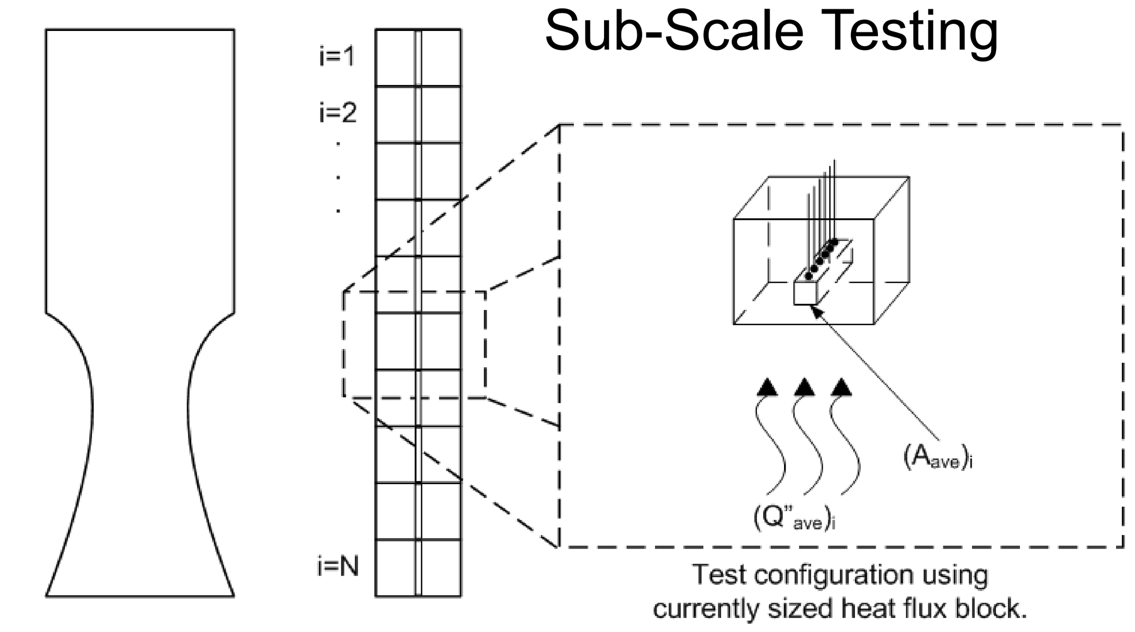
OBJECTIVES & OUTCOMES

- 1st article design in testing at UTEP, based on Morpheus engine. 2nd test article and radial heating block in design review stage with enhanced instrumentation.
- JSC in-house design tool, Regeneratively Coooled Combustor Equilibrium Tool for Matlab (RCCET-M), baselined and in-use. Validation from UTEP data.

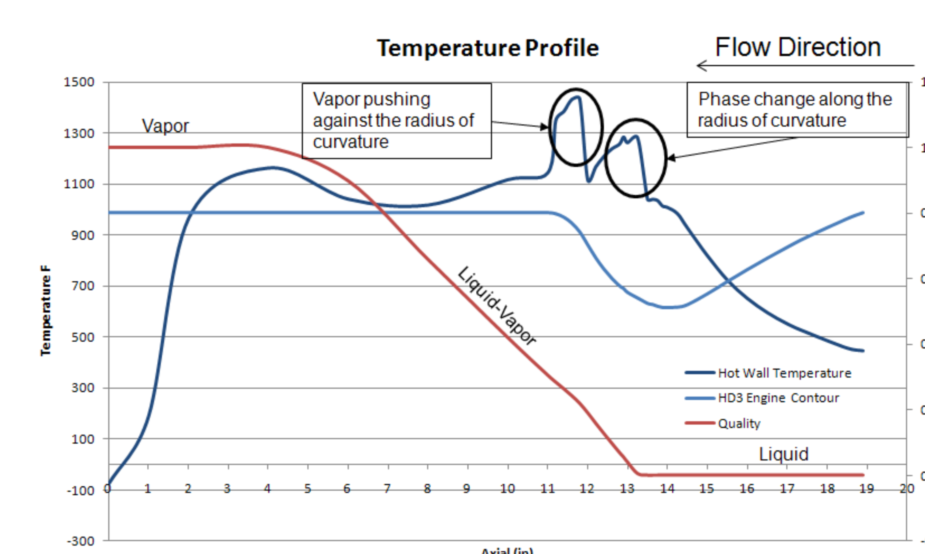
INFUSION POTENTIAL

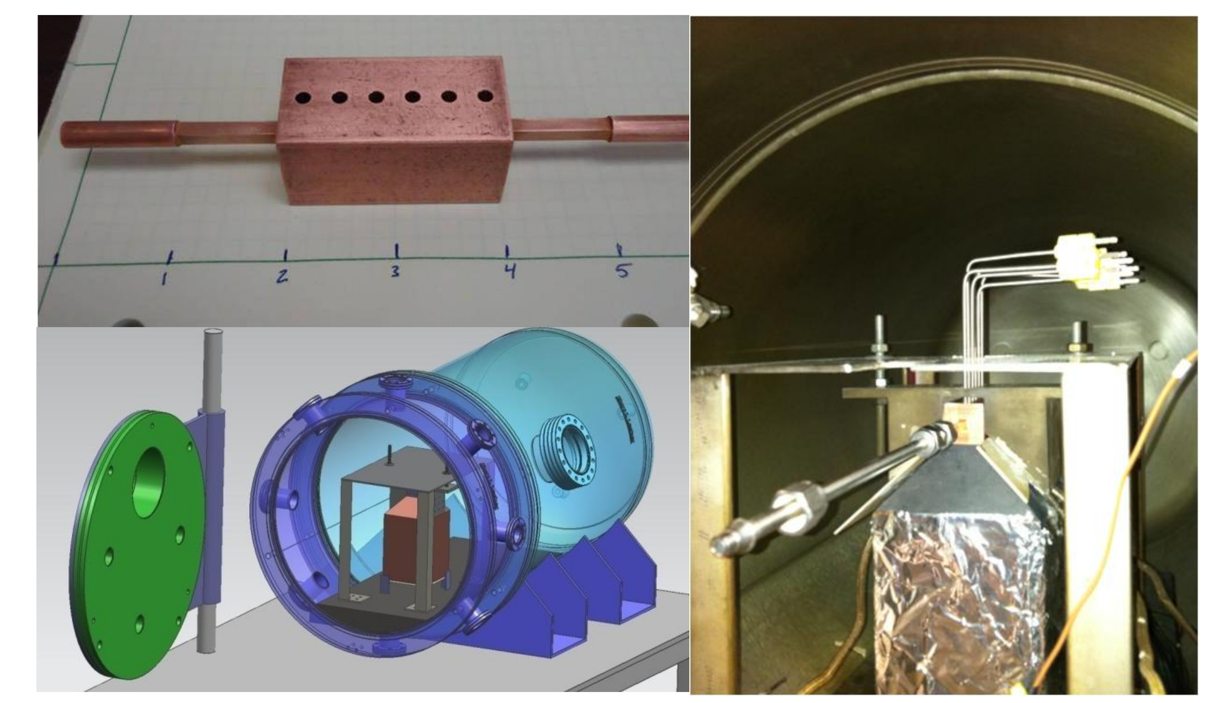
- Regen-cooled main engine technology will be used on the Human Exploration and Operations Mission Directorate (HEOMD) Advanced Exploration Systems (AES) Project Morpheus vertical test bed, enabling lunar lander and ISRU tech demo missions





RCCET-M Model Results

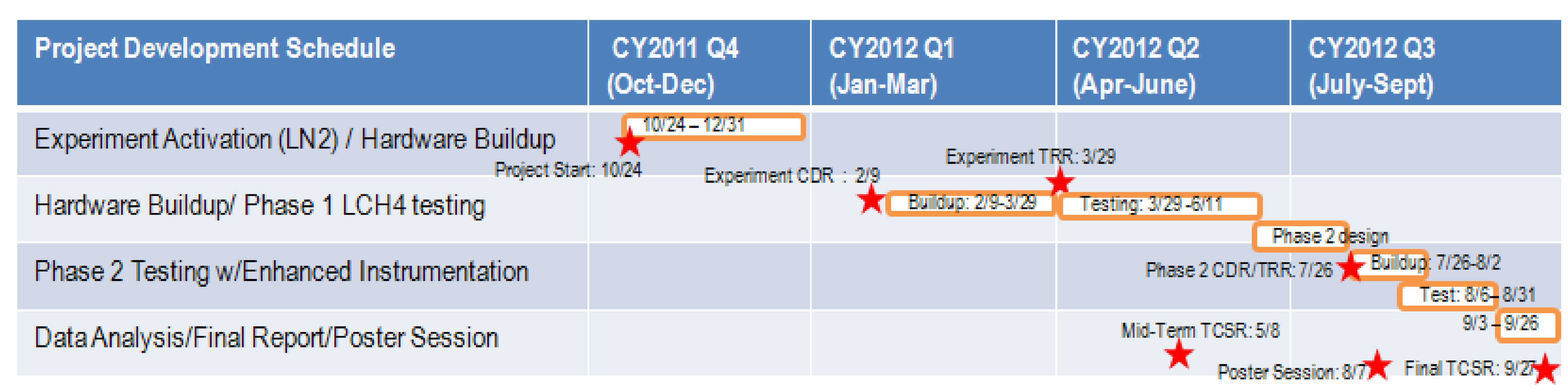




NASA TECHNOLOGY AREA ROADMAP

•Regen engine heat transfer studies enable high-performance cryogenic LO2/Methane propulsion: TA 2.0 In-Space Propulsion Technology, 2.1 Chemical Propulsion, 2.1.2.1 liquid cryogenic LO2/CH4 .

PROJECT DEVELOPMENT SCHEDULE



Project Start TRL (1-9): 3
Current TRL (1-9): 4

Appendix C

JSC FY’12 CIF Support Project Details
Directorate-Level IR&D

Multi-Phase Flow Experiment for Suborbital Testing (MFEST)

PROJECT MANAGEMENT

Kathryn Hurlbert, Ph.D., EC8/Special Projects Branch, x34546, katy.m.hurlbert@nasa.gov, & Ralph Marak, EC7/Tools & Equipment Branch

PROJECT OVERVIEW

- The primary objective of MFEST is to conduct a pathfinder, suborbital flight experiment that focuses on two-phase fluid flow and separator operations through a representative launch, suborbital, and entry profile

RELEVANCE/ VALUE TO NASA

- MFEST will test a two-phase flow system and vortex separator concept under representative suborbital launch, zero-g, and entry; two-phase flow and separators are used in numerous technical areas (e.g., life support, thermal systems, science)

OBJECTIVES & OUTCOMES

- Hardware and documentation located and rejuvenated; precursor ground testing is continuing, and parabolic flight testing is scheduled for September 2012
- Partnerships in place with Space Engineering Research Center (SERC) at Texas A&M, and Advanced Cooling Technologies (ACT)

INFUSION POTENTIAL

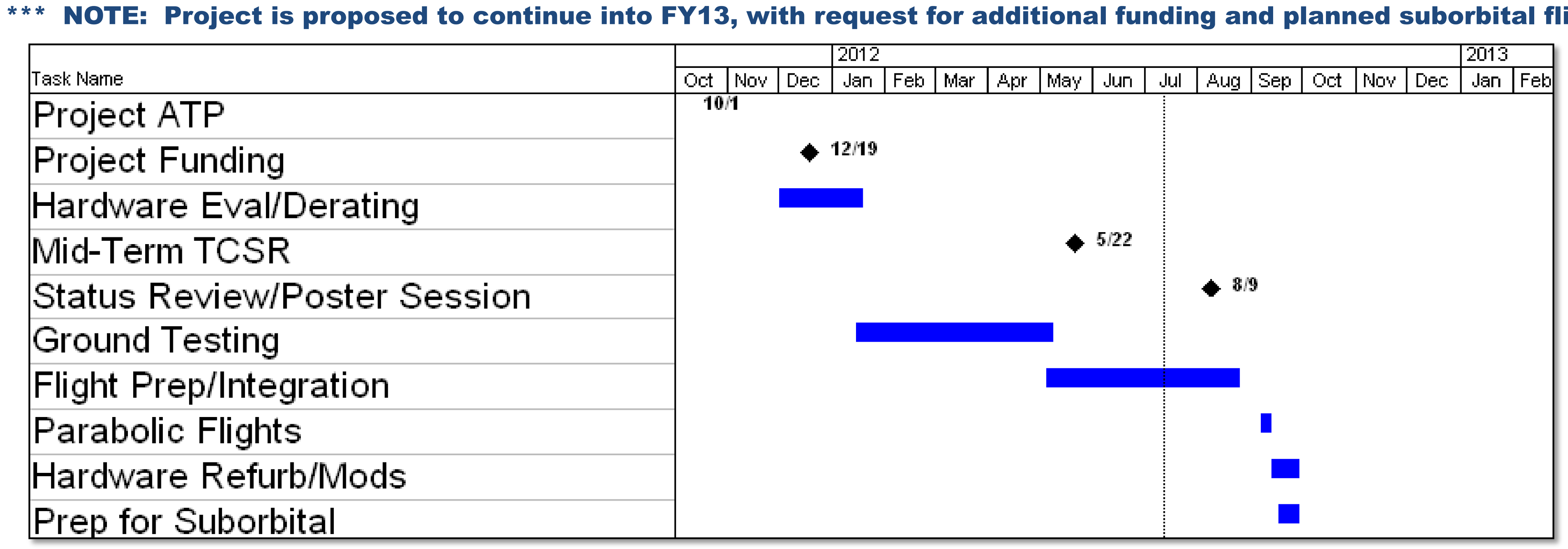
- The separator is suitable for both ground and aerospace applications, but has not yet been tested for long-duration space environment as proposed herein
- ACT is one commercial company that intends to market the separator for commercial and government applications

NASA TECHNOLOGY AREA ROADMAP

- The proposed experiment can be applicable to technologies designated in multiple draft OCT Space Technology Roadmaps:
  - TA02, In-Space Propulsion Technologies
  - TA03, Space Power and Energy Storage
  - TA06, Human Health, Life Support and Habitation Systems
  - TA07, Human Exploration Destination Systems
  - TA14, Thermal Management Systems

PROJECT DEVELOPMENT SCHEDULE

*** NOTE: Project is proposed to continue into FY13, with request for additional funding and planned suborbital flight



Project Start TRL: 5
Projected TRL: 7/8

LOX/Methane Regeneratively-Cooled Rocket Engine Development

PROJECT MANAGEMENT

Rob Morehead/EP4, Lee Wilson/ES6
281-224-5670, robert.l.morehead@nasa.gov;
281-483-8533, robert.l.wilson@nasagov

PROJECT OVERVIEW

- Using liquid methane as a coolant, design, build, and test fire a regeneratively cooled oxygen/methane combustion chamber.
- Develop low-cost processes to model and test high heat flux heat transfer into subcritical liquid methane.

RELEVANCE/ VALUE TO NASA

- Methane is non-toxic, space storable, and producible on foreign planets…but few full-scale methane engines have been developed.
- This project will markedly improve the NASA knowledge base for methane and subcritical regeneratively cooled engines.

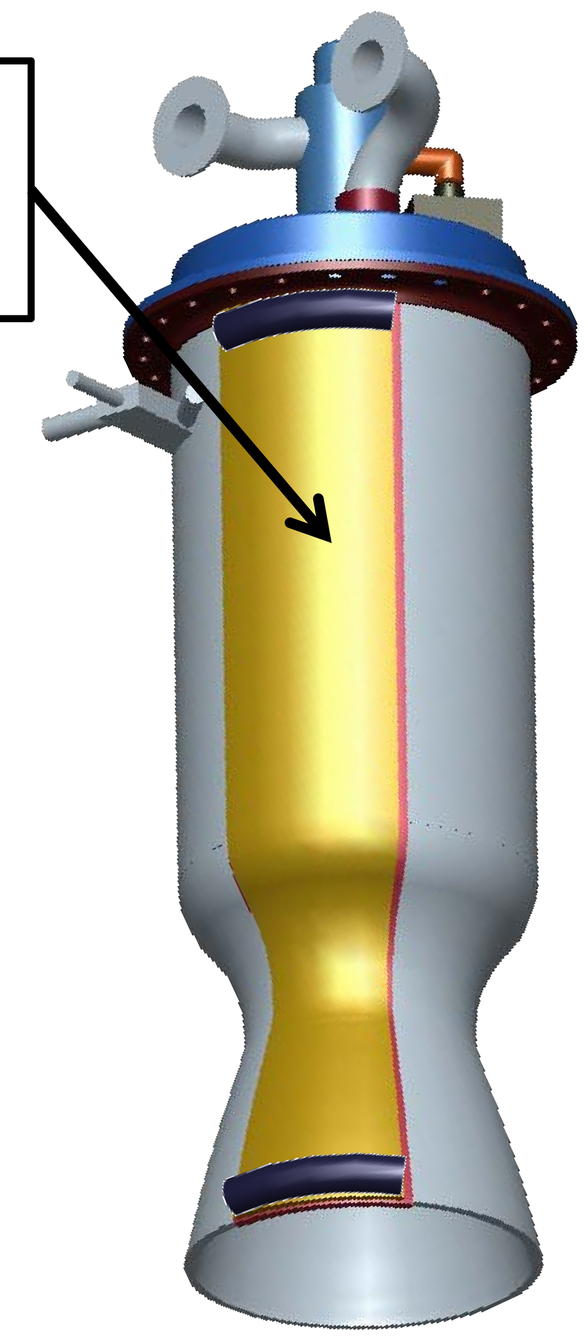
OBJECTIVES & OUTCOMES

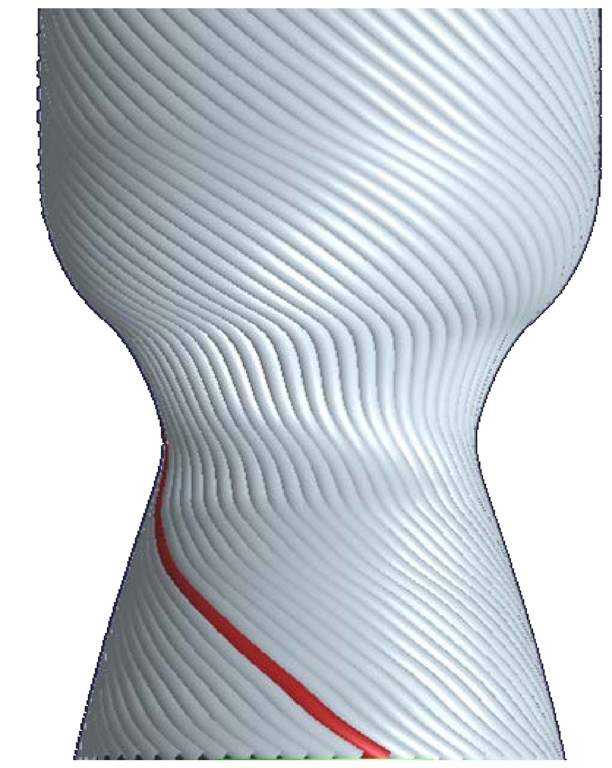
- Phase 1 experiment in manufacture; fluid passages designed using code developed under companion center-level IR&D project (Multi-Phase Methane Heat Transfer). Studies for phase 2 full-scale chamber in work.
- Deliverables: a Morpheus-class functional combustion chamber, validation for JSC's regenerative cooling heat transfer model, and publishable test data from hot-fire tests.

INFUSION POTENTIAL

- This project will provide baseline data for any future methane-based regeneratively cooled rocket engines, such as for Morpheus-type landers or those that burn methane produced by an ISRU reactor
- This technology could also be used in commercial applications for high-Q heat exchangers using liquid methane as the coolant.

Phase 1: Regen test section added to existing JSC LOX/Methane Engine





Proof of concept for potential manufacturing method of Phase 2 full-scale regen chamber: Single-pass constant-diameter tubing brazed to form solid wall (plastic shown here)

NASA TECHNOLOGY AREA ROADMAP

- This project enables high-performance cryogenic LO2/Methane propulsion: TA 2.0 In-Space Propulsion Technology, 2.1 Chemical Propulsion, 2.1.2.1 liquid cryogenic LO2/CH4 .

PROJECT DEVELOPMENT SCHEDULE

Project Development Schedule	2011 Q4	2012 Q1	2012 Q2	2012 Q3	2012 Q4
Analytical Modeling and Sub Scale Testing		11/1/11 – 8/15/12			
Partial Regen Chamber Dev. and Testing			1/20– 9/15		
Partial Regen CDR			5/1 7 ★		
Full Scale Combustion Chamber Design				4/21-9/31	
Mid-Term TCSR			6/5 ★		
Full Scale Chamber CDR				9/31 ★	
Full Scale Chamber Manf. and Testing					9/1-12/15
Final TCSR / Final Report				8/20 ★	1/15/13 ★

Project Start TRL (1-9): 3
Current TRL (1-9): 4
Project End TRL (1-9): 5

Flight Deck of the Future: Electronic-textile System for the Evaluation of Wearable Technology (E-SEWT)

PROJECT MANAGEMENT

Cory Simon, EV3; cory.l.simon@nasa.gov

Tim Kennedy, EV4; timothy.f.kennedy@nasa.gov

PROJECT OVERVIEW

The E-SEWT is a reconfigurable garment that integrates displays, controls, and sensors. Its modular interface allows for rapid prototyping of new functionality and its e-textile antennas enable accurate indoor tracking.

RELEVANCE TO NASA

The E-SEWT brings information and control to the astronaut, improving situational awareness and efficiency.

OUTCOMES

Developed Functioning Prototype s

- Removable electronic textile swatches
- Power and data network in garment
- Wireless data exchange with base station

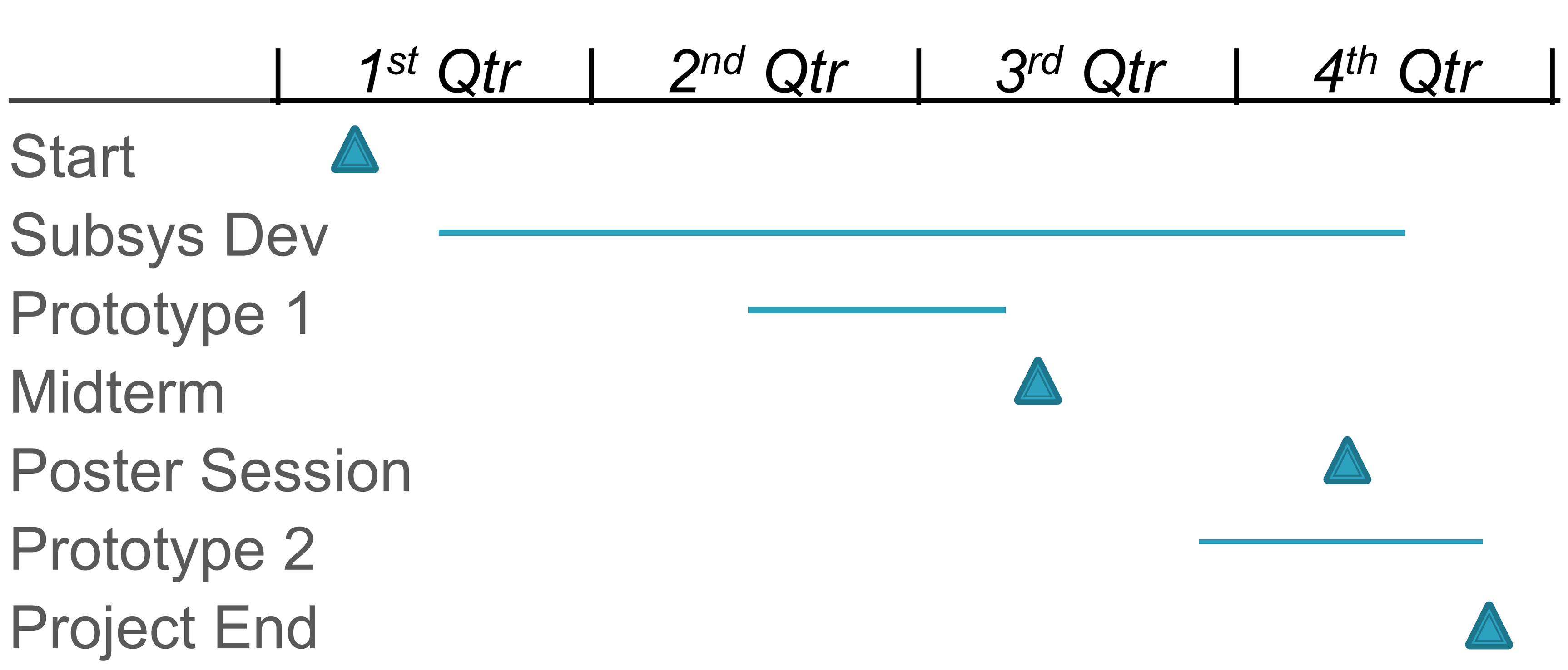
Developed new manufacturing processes

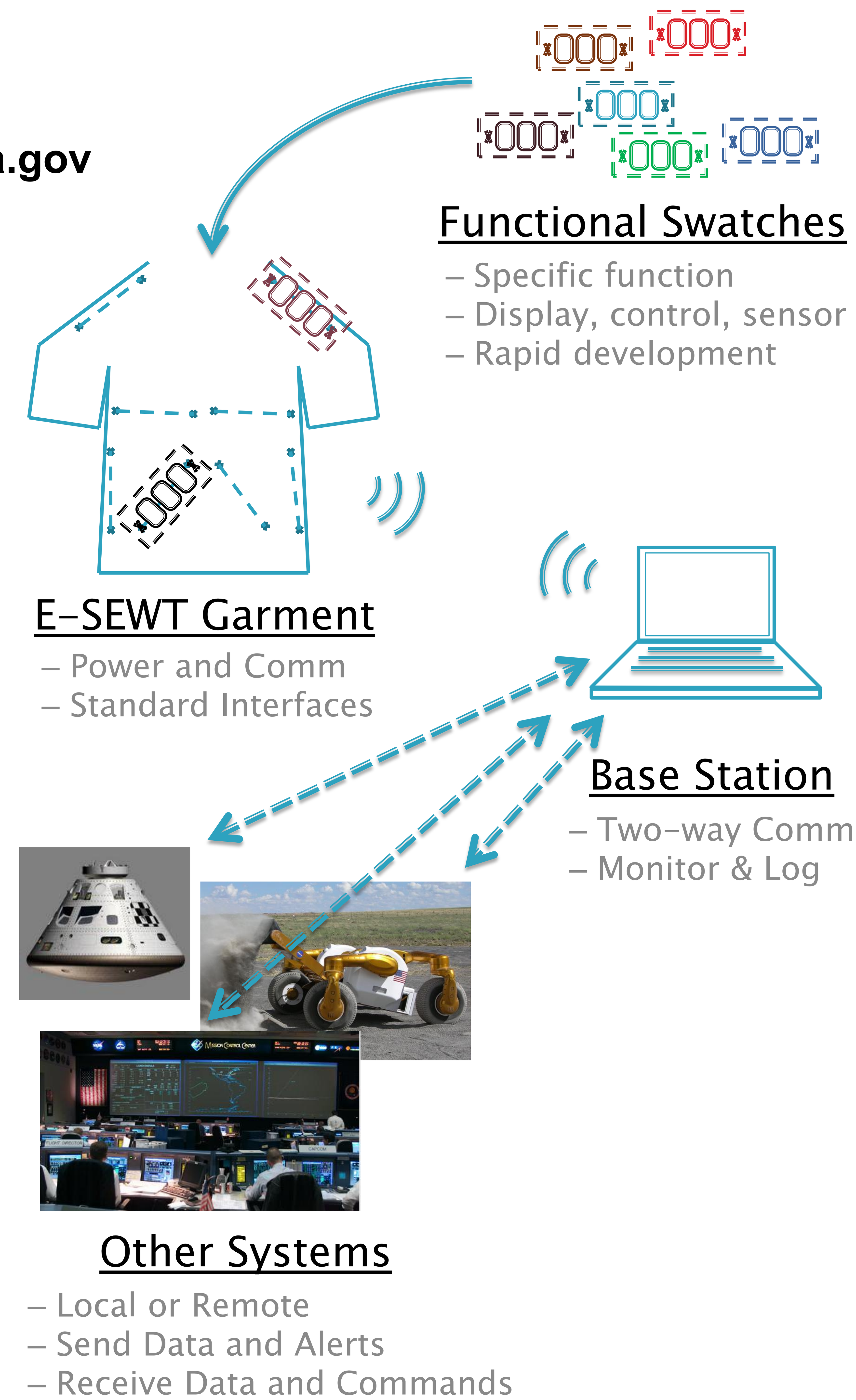
Established university partnerships

NASA TECHNOLOGY ROADMAP

- TA05 Communication & Navigation; TA06 Human Health, Life Support & Habitation; TA07 Human Exploration Destination; TA04 Robotics, Tele-Robotics and Autonomous Systems

DEVELOPMENT SCHEDULE





INFUSION POTENTIAL

E-textile antennas will be integrated into Robonaut 2 for use on ISS. The E-SEWT prototype will be integrated into the Flight Deck of the Future for testing and use during IPAS evaluations.

E-SEWT technology and processes have applications in health, sport and extreme environments. University and industry partnerships will help facilitate commercial infusion.

Project Start TRL (1-9): 3

Current TRL (1-9): 4-5

Virtual Windows

PROJECT MANAGEMENT

Helen Neighbors/EV3 (Lead); Collaborators: T. Scott West/WE, Shelby Thompson/SF3, Max Haddock/EV3

helen.neighbors@nasa.gov; x30811

PROJECT OVERVIEW

- Investigate the potential benefits of Virtual Windows in future space craft design via real-time video scene-stitching using images from multiple cameras, plus alternative display configurations and control input methods for scene and perspective change.

RELEVANCE/ VALUE TO NASA

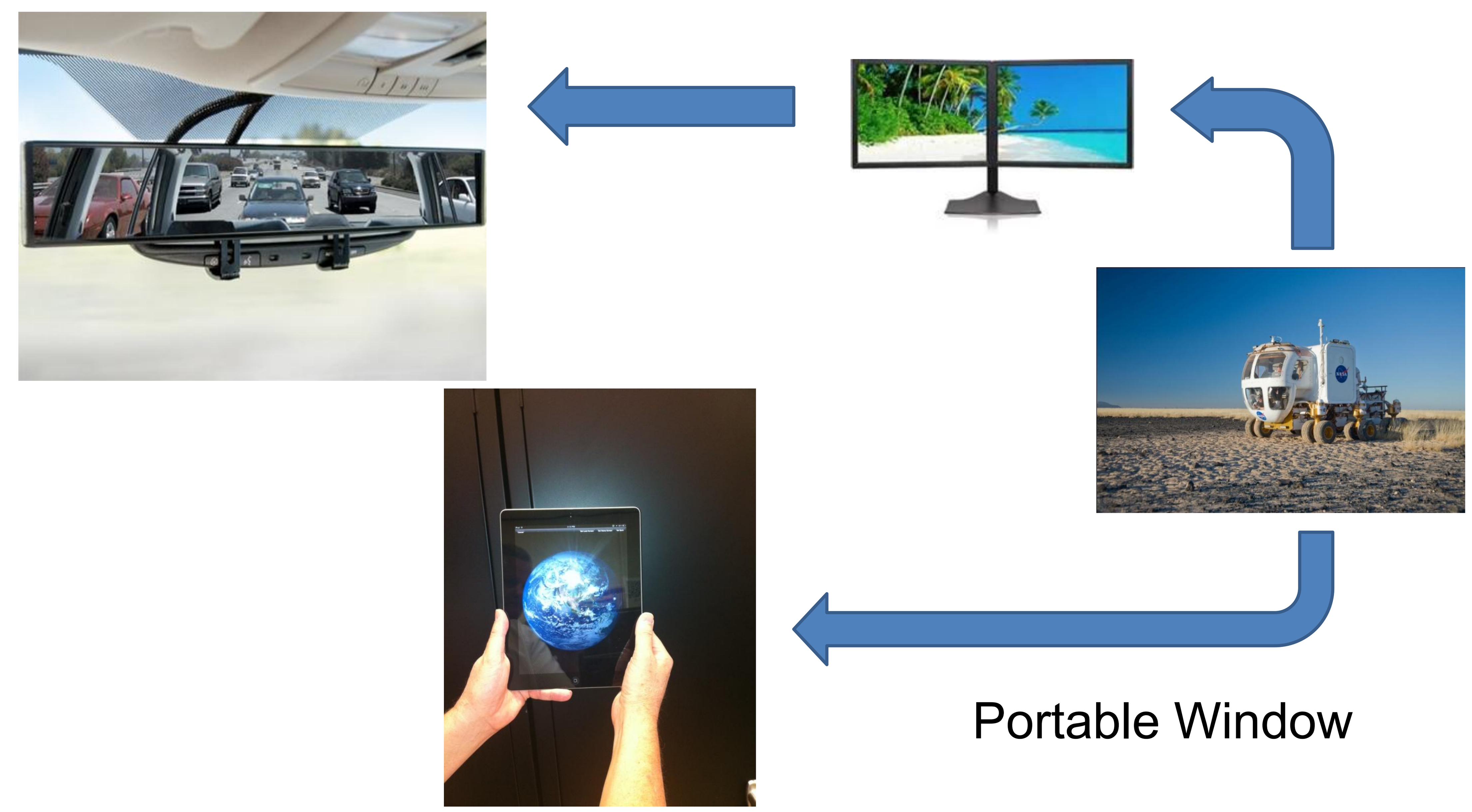
- Virtual Windows can enhance external viewing capability beyond available physical windows and may aid in psychological health on long duration missions.

OBJECTIVES & OUTCOMES

- Develop low latency solution for real time video scene-stitching of multiple camera images
- Further assessment of portable window and display tiling concepts
- Demonstrate and evaluate capability in operational setting

INFUSION POTENTIAL

- System prototypes to be deployed on Gen1B MMSEV rover to evaluate effectiveness in eliminating blind spots.
- Real time video aspect could supplement or replace recorded video used in commercial applications wherein interactive and scenic views are utilized for aesthetic and psychological benefits.



NASA TECHNOLOGY AREA ROADMAP

- Virtual Windows applies to TA07.4 Advanced Habitat Systems by supplementing the number of real windows required in future spacecraft and helping to assure crew psychological heath

PROJECT DEVELOPMENT SCHEDULE

Project Development Schedule:	FY' 12
	| 1st Qtr | 2nd Qtr | 3rd Qtr | 4th Qtr | 1st Qtr
• FY'12 Project start	▲10/31
• *Planning & Design*	|------------|
• *Procurements*	|------------------------------|
• *FPGA Development*	|----------------------------|
• Mid-term TCSR & Demo	▲3/27
• Integration & Test	|--------------|
• Final Demo , TCSR & Report	▲11/30

Project Start TRL (1-9): 2

Current TRL (1-9): 3

GeoLab Robotic Sample Manipulator

PROJECT MANAGEMENT

Cynthia Evans, Ph.D., KT; p. (281)483-0519; cindy.evans-1@nasa.gov; Michael Calaway and Mary Sue Bell, Ph.D. KT/Jacobs ESCG

Collaborators: Zheng Li, Ph.D., University of Bridgeport (2012 X-Hab Challenge Award)

PROJECT OVERVIEW

- Design/ build prototype geological sample holder for GeoLab glovebox in the Deep Space Habitat (DSH). Leverages from earlier GeoLab work and 2012 collaboration with U. of Bridgeport; this proposal extended the Bridgeport product for full glovebox operations by including a translation track, increasing the DOF and whole-glovebox operations, and including motors and controllers for remote control, enabling precise sample control and efficient crew operations.

RELEVANCE/ VALUE TO NASA

- Tests science operations and surface-based curation protocols for sample manipulation and preliminary examination in a reduced gravity environment. Tests robotic tools for human science operations.

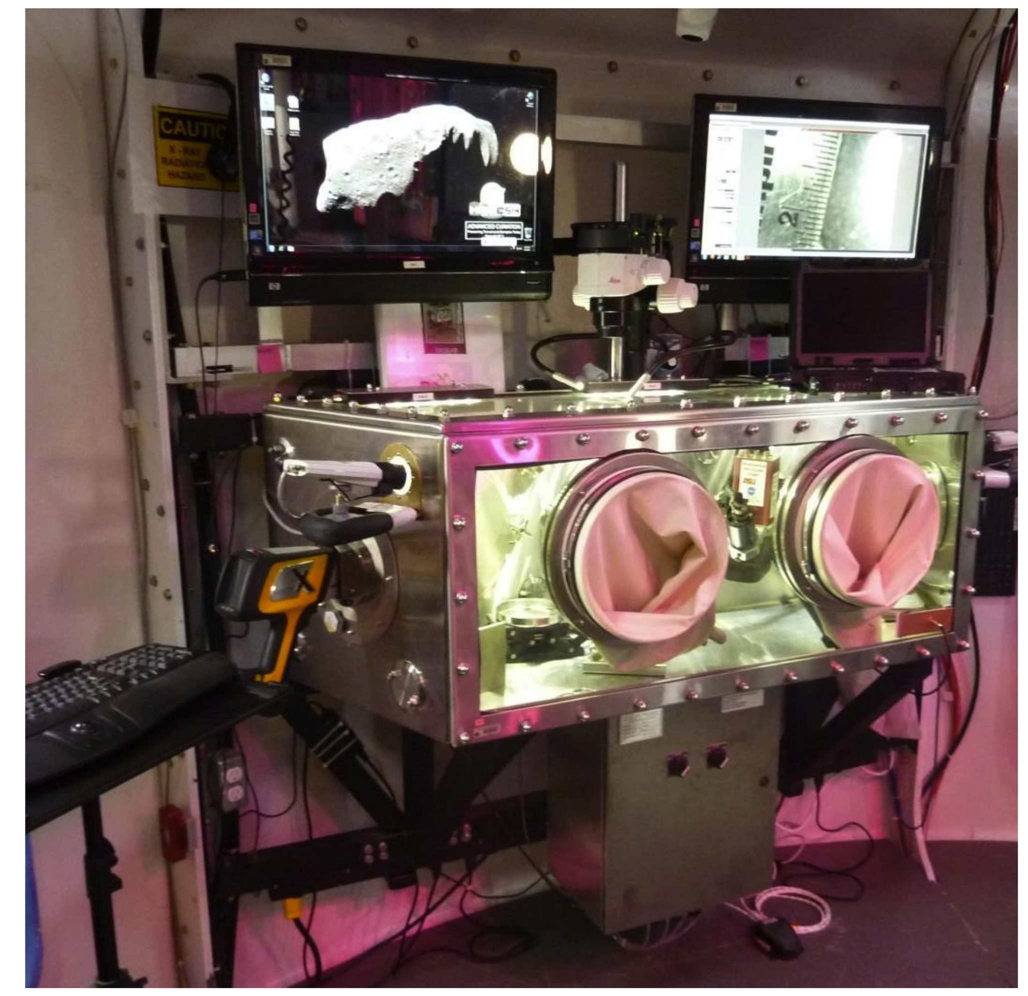
OBJECTIVES & OUTCOMES

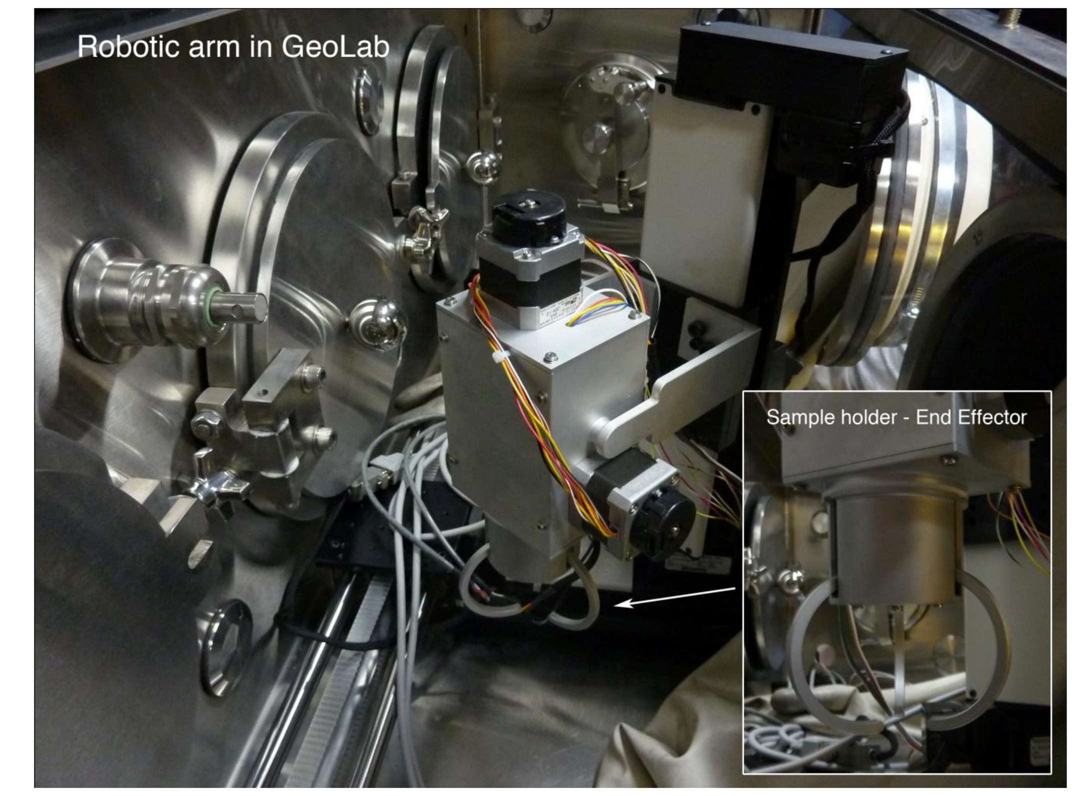
- Integrate a robotic sample manipulator in the DSH-based GeoLab to assist astronauts and support scientists in preliminary examination of astromaterials. Addresses recommendations about enhanced, efficient glovebox operations; increased geometric control of examination. Leverages human activities with robots.

INFUSION POTENTIAL

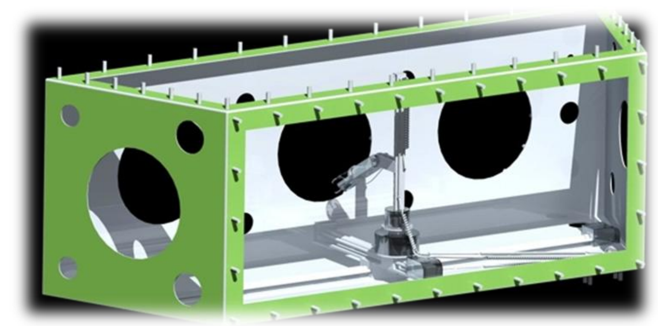
- Infusion strategy: GeoLab operational test results are folded into AES science operations concepts, including definition of geoscience sample handling protocols and tools. Enables future partnerships with new glovebox and clean room technologies.

Project Start TRL (1-9): 3 Current TRL (1-9): 4-5





Left: GeoLab integrated into DSH
Top: Robotic arm inside GeoLab



CAD models: inside glovebox; end effector.

NASA TECHNOLOGY AREA ROADMAP

TA04 Robotics (Human Systems Interactions), TA07: Human Exploration Systems (Integrated Habitat systems). TA08: Science Instrumentation, TA11: Modeling, Simulation, IT (Collaborative science/ engineering)

PROJECT DEVELOPMENT SCHEDULE

GeoLab Robotic Manipulator	Sept-Oct	Nov-Dec	Jan-Feb	Mar-Apr	May-Jun	Jul-Aug	Sept
Robotic Arm SDR	X						
Robotic Arm PDR and CDR		X					
Construction and Progress Repors			X	X			
Delivery to JSC					X		
Mid-term TCSR					X		
Integration into GeoLab and DSH						X	
Procedure Development and Training						X	
Preliminary Tests, final DSH operations						X	X
IR&D Poster and Final Report						X	X

Curation Technology for Future Sample Return Missions: Organic Cleanliness Baseline Study

PROJECT MANAGEMENT

Carlton C. Allen, Michael J. Calaway, Judith H. Allton, and Patti J. Burkett
Astromaterials Acquisition and Curation Office (KT)
281-483-5126; carlton.c.allen@nasa.gov

PROJECT OVERVIEW

Future human and robotic missions to the Moon, Mars, asteroids and comets will require handling and storing atromaterial samples free of inorganic and organic contamination and possibly preserving these samples at low temperatures. Current astromaterial collections from the Apollo, Genesis, and Stardust missions have mainly been concerned with inorganic contamination for clean preservation at ambient temperatures. Little is known about the current state of organic contamination in JSC curation laboratories. This project was developed to determine a baseline for current curation technology and test how well existing curation cleaning procedures lowered organic contamination. The results provide a foundation to develop new cleaning procedures that would result in lowering organic contamination for handling and long-term storage of future returned samples. In addition, the results from this study enable new technology and techniques to be used in current curation facilities and help develop the next generation sample return missions.

RELEVANCE/ VALUE TO NASA

The *Planetary Science Decadal Survey 2013 - 2022* recommended Mars, Moon, asteroids and comets as the highest priority sample return missions. In support of these missions, the Decadal Survey stated that such missions "present new challenges, including curation of organics uncontaminated by Earth's biosphere and volatiles requiring low temperature curation and distribution."

OBJECTIVES & OUTCOMES

- Detailed understanding of organic contamination levels through time in Astromaterials Curation laboratories – **ACCOMPLISHED**.
- Decreased organic contamination in Astromaterials Curation laboratories – **COMPLETE IN YEAR 2**
- Proven techniques and equipment to support new sample return missions with increasingly stringent requirements for organic contamination control – **COMPLETE IN YEAR 3**.

INFUSION POTENTIAL

- This project will directly improve current Astromaterials Curation laboratory operations and lay the groundwork for sample curation of all future human and robotic missions.
- State-of-the-art cleaning and monitoring developed for handling returned samples have direct application to NASA hardware cleaning requirements and potential use for the biotechnology, semiconductor, and nanotechnology industry.

Advanced Curation Cabinet

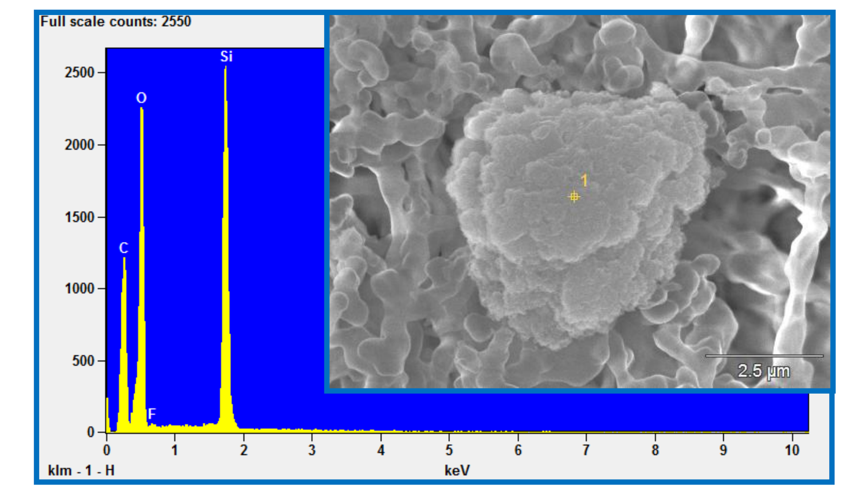
Gas collection by organic absorbent tube, pumped for 6 hours for TD-GS-MS analysis

Lunar Processing Cabinet

Two sets of 8 inch Silicon Wafers Exposed for 24 hours for TD-GS-MS analysis

List of Organic Testing

- Airborne molecular organics by pure Si wafer exposure for Thermal Desorption Gas Chromatography Mass Spectroscopy (TD-GC-MS) analysis.
- Airborne molecular organics by absorbent tube for Thermal Desorption Gas Chromatography Mass Spectroscopy (TD-GC-MS) analysis.
- Surface organics on stainless steel by exposure of Methylene Chloride solvent with NVR/FT-IR spectroscopy and Gas Chromatography Mass Spectroscopy (GC-MS) analyses.
- Liquid particle counts of all ultrapure water used for cleaning
- Organic particle identification by Scanning Electron Microscopy (SEM) on Millipore filters used during cabinet cleaning procedure.



Possible oxidized silicone particle

Detected Organics by TD-GC-MS	Lunar Processing Cabinet AP-11, 307-41			Advanced Curation Cabinet		
	Vertical Wafer Exposure (ng/cm²)	Surface Wafer Exposure (ng/cm²)	Organics in Air Absorbent Tube (ng/L)	Vertical Wafer Exposure (ng/cm²)	Surface Wafer Exposure (ng/cm²)	Organics in Air Absorbent Tube (ng/L)
Hydrocarbons						
Low boilers C7-C10	< 0.1	0.2	1.2	0.4	0.4	0.6
Medium boilers >C10-C20	1.8	2.5	3.8	7.1	9.6	18.8
High boilers >C20	0.1	0.2	< 0.1	1.1	1.8	0.1
Sum >= C7	1.9	2.9	5	8.6	11.8	19.5

Hydrocarbon results show that a new type of degreaser is needed to replace the Apollo era Freon 113 cleaning to further reduce organic contamination levels.

NASA TECHNOLOGY AREA ROADMAP

- TA07: Human Exploration Systems (Integrated Habitat and science systems)
- TA08: Science Instrumentation

PROJECT DEVELOPMENT SCHEDULE

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Start Project												
Historical Data Compilation												
Advanced Cabinet Cleaning												
Lunar Cabinet Cleaning												
Cabinet Testing												
Mid-term TCSR												
Interpret Results												
Poster Session												
Final Report												

Project Start TRL (1-9): 3
Current TRL (1-9): 4

Habitat Particle Impact Monitoring System (HIMS)

PROJECT MANAGEMENT

John N. Opiela (ESCG/Jacobs; john.n.opiela@nasa.gov, x33594),
Eugene Stansbery (KX)

PROJECT OVERVIEW

- The HIMS is designed to monitor particle impacts that could damage a habitat structure during a future exploration mission.
- System performance must be characterized on flexible, inflatable structures.

RELEVANCE/ VALUE TO NASA

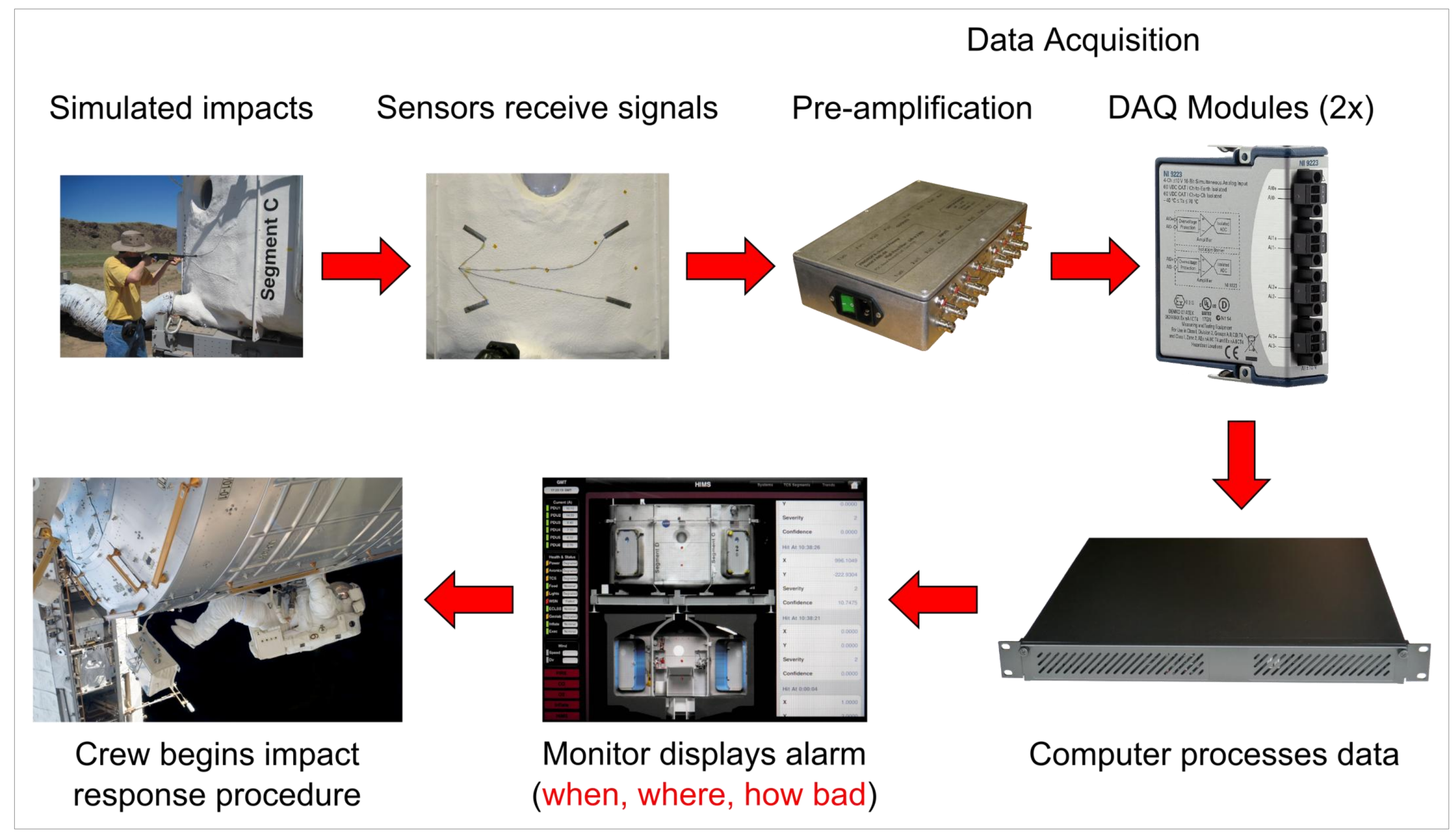
- This mission-enabling technology will improve the safety of future human exploration missions.

OBJECTIVES & OUTCOMES

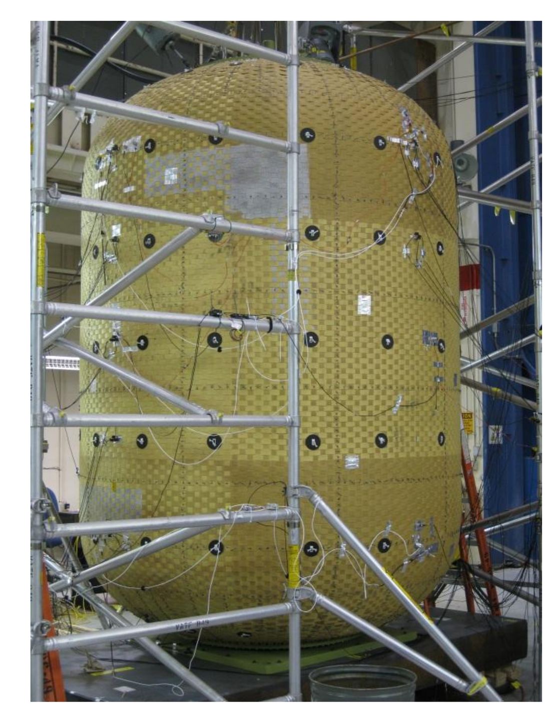
- Experimental data will determine maximum sensor spacing, and hence the number of sensors needed to adequately monitor the structure.
- A report will outline the design, requirements, and anticipated capabilities of a total-structure impact detection system based on this technology.

INFUSION POTENTIAL

- HIMS participates in the AES Habitation Systems Project, with long-term plans for flight demonstration (ISS-docked and deep-space).
- Include HIMS technology in NASA/commercial partnerships currently studying inflatable space habitats.



Testing and evaluation on inflatables.



NASA TECHNOLOGY AREA ROADMAP

- Human Exploration Destination Systems - TA07
  - 7.4.1.2 Internal Systems & Outfitting
  - 7.5.2.2 MMOD & Secondary Ejecta Protection

PROJECT DEVELOPMENT SCHEDULE

Tasks	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
FY12 Project start				Δ								
Identify and acquire samples												
Design and fabricate test fixture												
Conduct low velocity tests												
Hypervelocity tests												
Mid-term TCSR									Δ			
Follow-up tests if needed												
Analysis												
Report development												
Final report delivered												Δ

Project Start TRL (1-9): 2
Current TRL (1-9): 3

GIS Technology – Resource and Habitability Assessment Tool

Carlton Allen and Dorothy Oehler / Astromaterials Research and Exploration Science (KA)
3-5126 / 3-4259 carlton.c.allen@nasa.gov | dorothy.z.oehler@nasa.gov

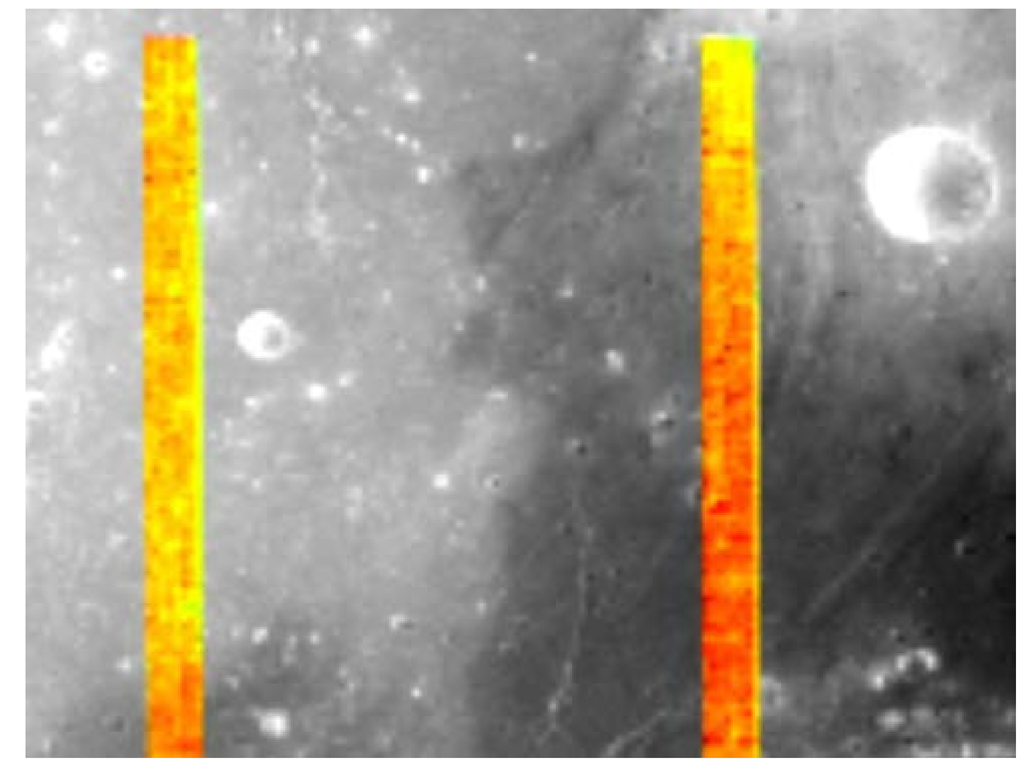
PROJECT OVERVIEW – We are applying Geographic Information Systems to new orbital data sets for Lunar resource assessment and the identification of past habitable environments on Mars. GIS has not previously been used for planetary resource assessment and its applicability to Martian habitability is in its infancy.

RELEVANCE / VALUE TO NASA

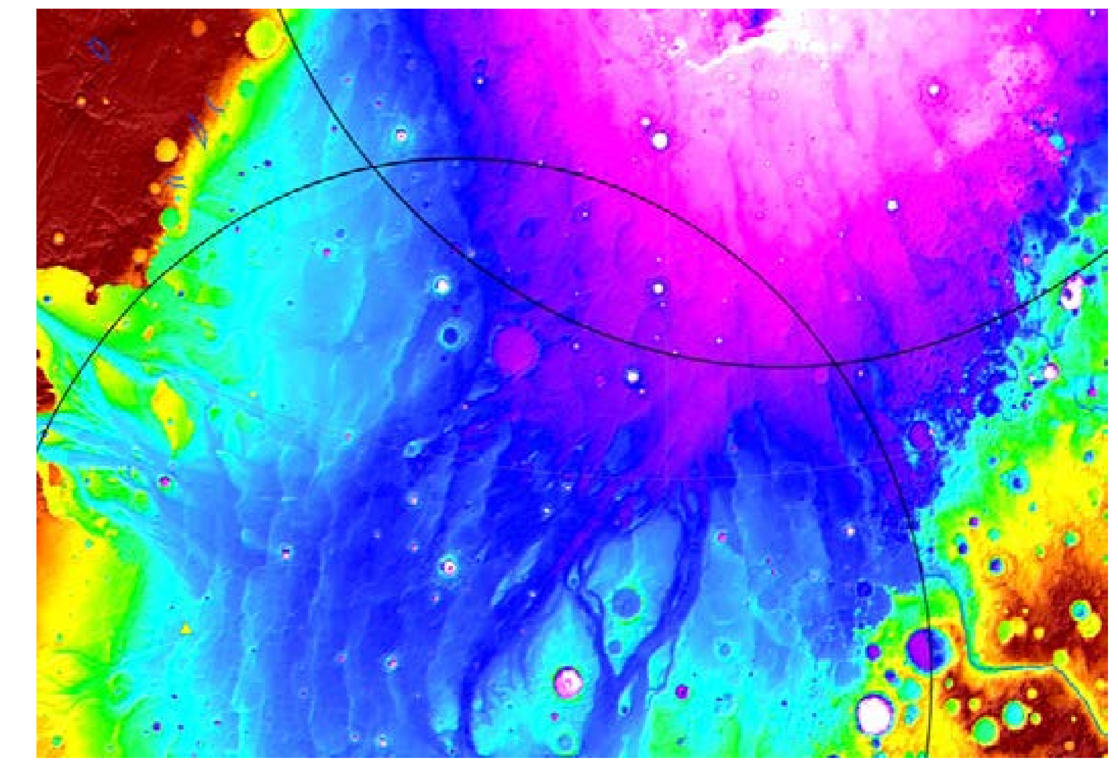
- Lunar Resource Assessment -- key to future exploration and sustainability
- Martian Habitable Environments – top priority Mars program goal
- New research and analysis capability for JSC / KA

OBJECTIVES & OUTCOMES

- Map lunar O_2 resources using data from the Lunar Reconnaissance Orbiter – **accepted for publication**
- **I**dentify sites on Mars having enhanced habitability and high potential to preserve organic biosignatures – **accepted for publication**
- **Dr. Dorothy Oehler was selected as a Participating Scientist on NASA's Mars Science Laboratory mission.**



Moon – Oxygen-rich deposit of volcanic ash



Mars – ancient floods and a possible ocean

INFUSION POTENTIAL

- Moon – lunar outpost site selection
- Mars – landing site selection
- Commercial – O_2 production at a lunar outpost

NASA TECHNOLOGY AREA ROADMAP

TA07 "*Human Exploration Destination Systems*"
Level II subtopic "*In-situ Resource Utilization*"

PROJECT DEVELOPMENT SCHEDULE

TASK	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Lunar Resource Assessment												
Integrate LRO orbital datasets into GIS			■	■	■							
Map pyroclastics; estimate resource					■	■	■	■				
Martian Habitability Analysis			■	■	■	■	■	■				
Mid-Term and Final TCSR's								■			■	
Prepare abstracts & papers for publication			■	■			■	■	■	■		

Project Start TRL (1-9): 3
Current TRL (1-9): 4

Green Monopropellant Detection and Decontamination Method Development

PROJECT MANAGEMENT

Benjamin Greene, NTEC-WSTF/RF 575.524.5761 benjamin.greene-1@nasa.gov

Mark B. McClure, NASA-WSTF/RF 575.524.5488 mark.b.mcclure@nasa.gov

PROJECT OVERVIEW

- High performance green monopropellants require means of detection and remediation of spills and residues. This project investigated color tests for spill detection and methods for remediation. Innovation was achieved using COTS test kits, and both fundamental and novel chemistry applied to the monopropellant ingredients.

RELEVANCE/ VALUE TO NASA

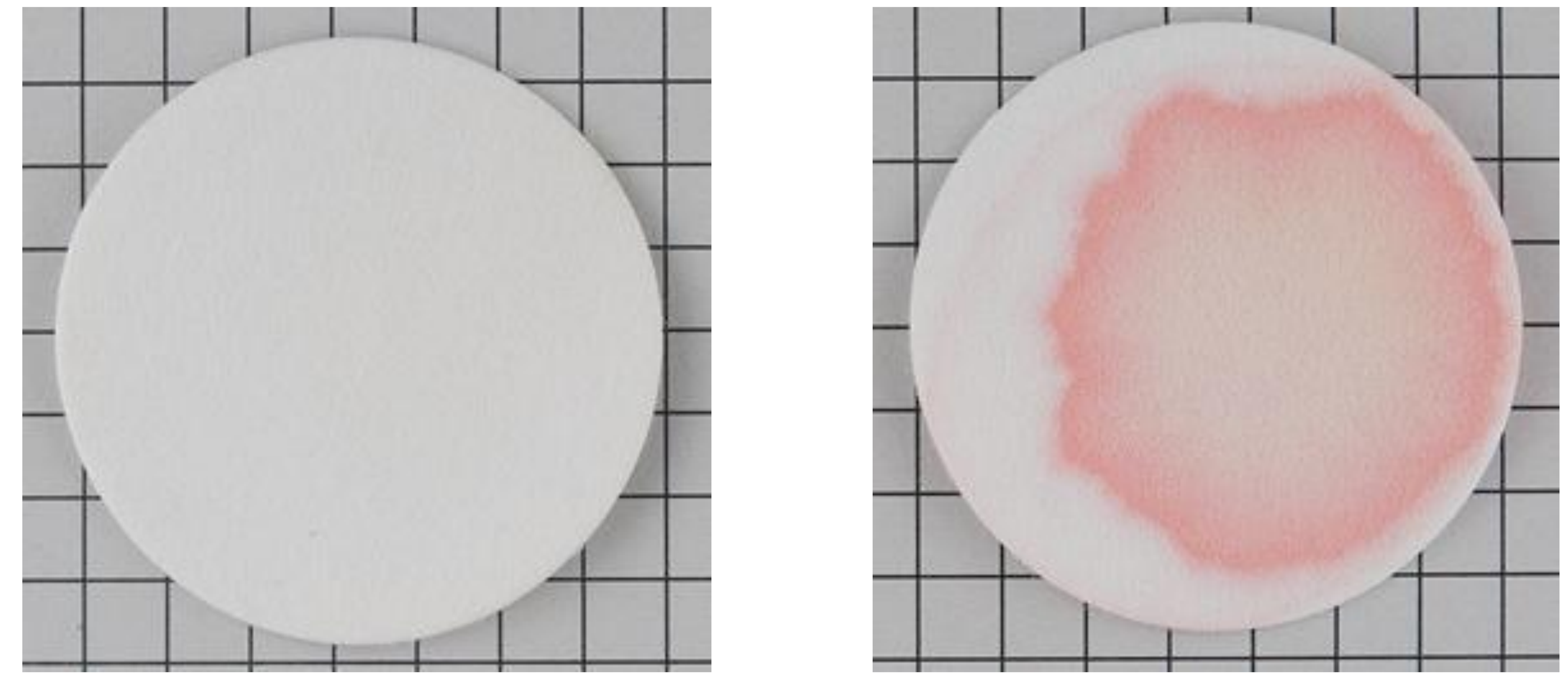
- NASA requires green alternative propellants
- Propellant spills must be detected and mitigated
- Detection and mitigation must be simple and reliable

OBJECTIVES & OUTCOMES

- Identify species for detection and mitigation and performed lab tests to obtain visual color changes
- Used COTS test strips, explosives test kits, and lab chemicals and obtained data
- Used instruments to investigate unexpected behavior
- A report will summarize the results of this activity

INFUSION POTENTIAL

- NASA's High Performance Green Propellant initiatives, DoD, DHS, and commercial entities can use these methods.
- The JANNAF Propellant and Explosives Development and Characterization Subcommittee can be a forum for insertion

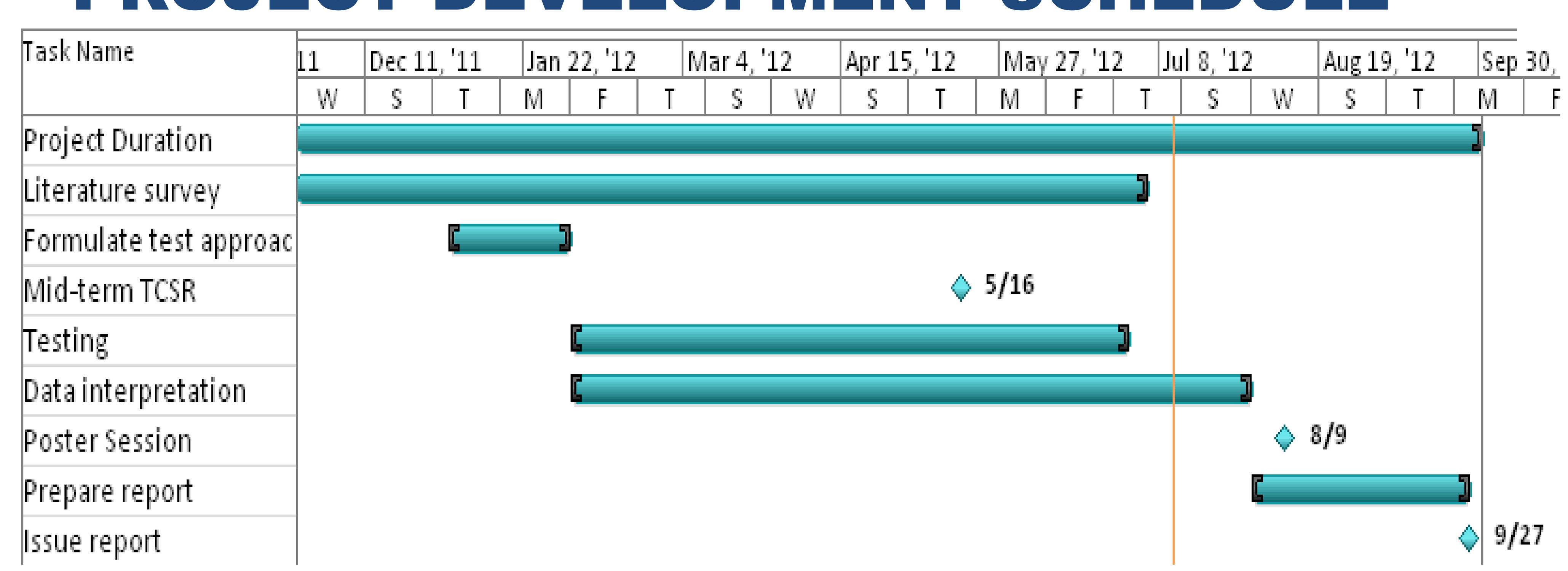


Propellant on a filter pad (L) exposed to an iron solution (R) provides visual detection

NASA TECHNOLOGY AREA ROADMAP

•This project is critical to NASA high performance green propellant initiatives TA02 WBS 2.1 Chemical Propulsion

PROJECT DEVELOPMENT SCHEDULE



Project Start TRL (1-9): #1
Current TRL (1-9): #4

Microgravity Cell Counter

Brian Crucian*, Heather Quiriarte, Terry Guess, Mayra Nelman-Gonzalez, Matthew Roper, Kathleen McMonigal, David Alrahwan and Clarence Sams

PROJECT OVERVIEW

- The ability to monitor hematology parameters during spaceflight is currently an unmet medical requirement (NASA-STD-3001). This project evaluated a DNA stain/CCD camera based technology to provide a White Blood Cell count + differential (granulocytes, lymphocytes, monocytes, eosinophils, basophils) analysis during microgravity conditions.
- This evaluated technology is miniaturized, lightweight, has few moving parts and operates on battery power. This technology generates a WBC and differential analysis. Sample is fingerstick blood ~10 microliters. Analysis time is ~3 minutes 20 seconds. Generates minimal biohazardous waste, no liquids for disposal.

OBJECTIVES & OUTCOMES

Task 1: Engineering evaluation/modification ✓

-Minimal modifications required to COTS base unit
-Battery power acceptable for flight
-Optical path sensitive to perturbation (.287 cm) but stable for flight
-Cuvette housing must be secured
-Double-magnetic delivery of cuvette to CCD camera appropriate for flight

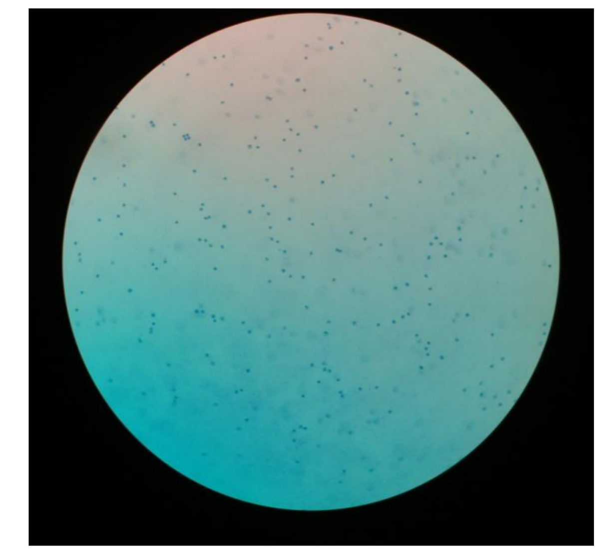
Task 2: Validation for medical/research sample types ✓

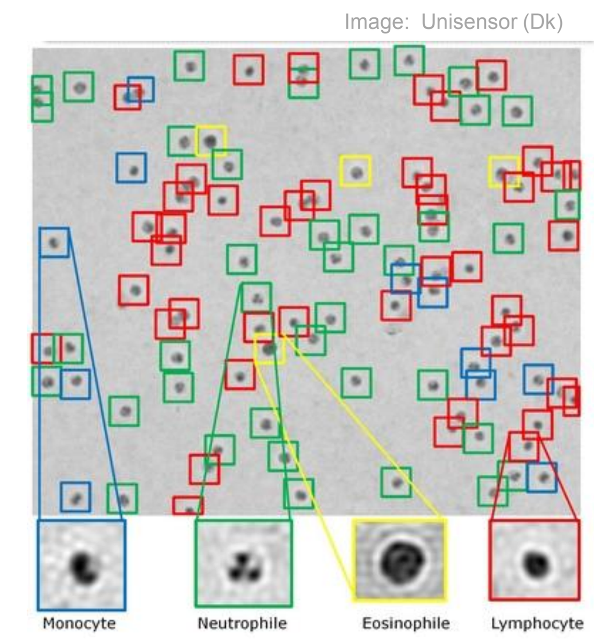
-Instrument analysis of both fingerstick and venous blood samples validated against laboratory standard
-Reagent stability acceptable
-Loaded cuvette stability acceptable
-Intra-cuvette precision acceptable
-Instrument precision found to be acceptable

Task 3: Validation during reduced gravity conditions ✓

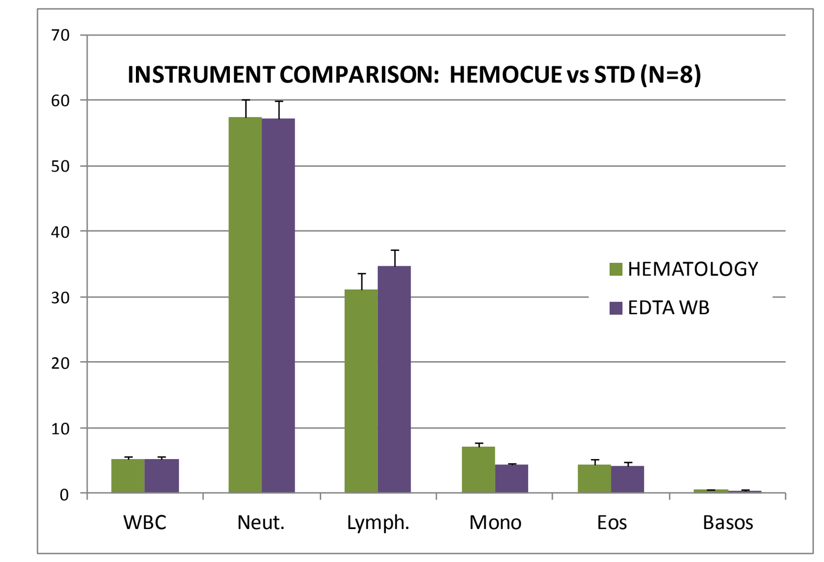
-Microgravity sample delivery (capillary action) acceptable
-Instrument functions in any gravity condition (0xG to 2xG)

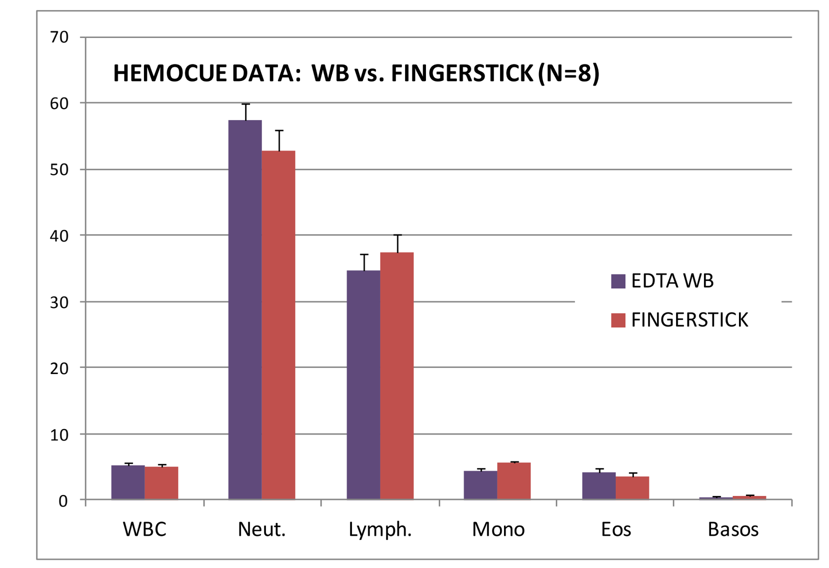
ANALYSIS



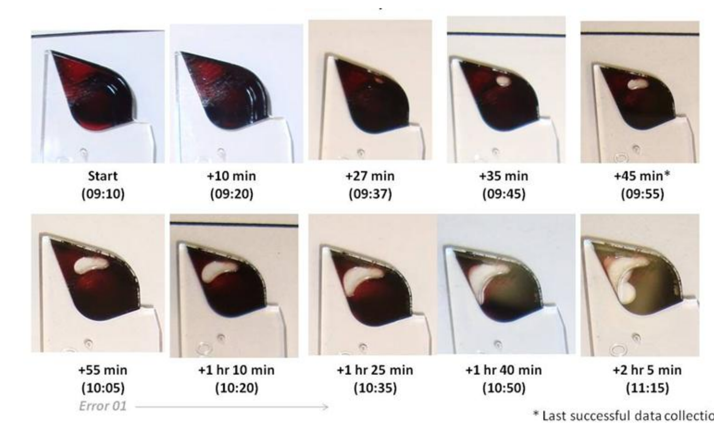


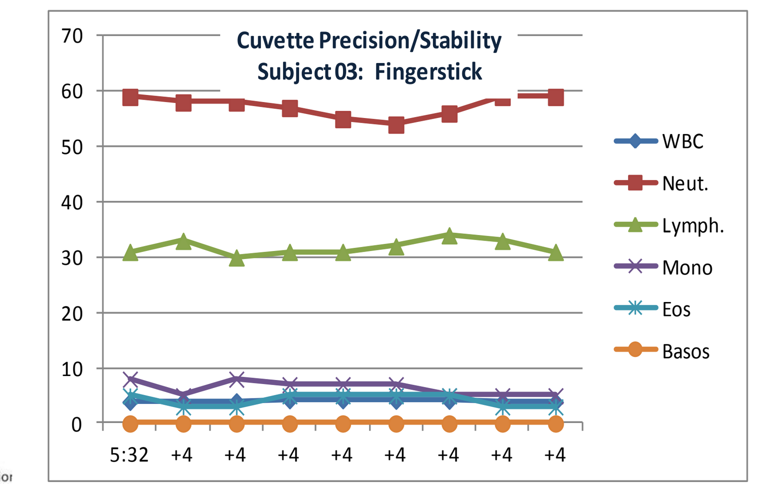
LABORATORY VALIDATION



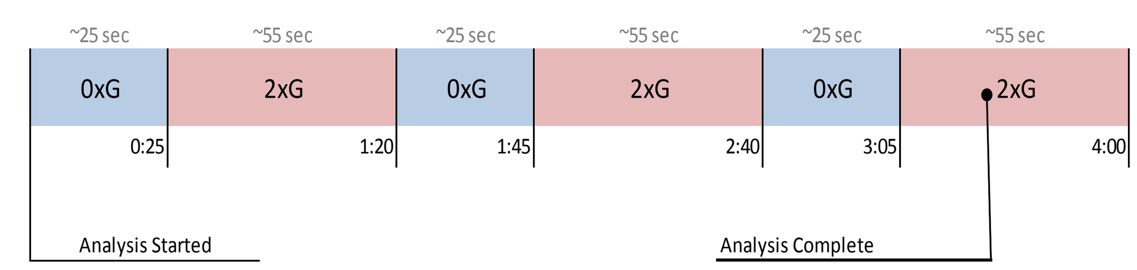


CUVETTE STABILITY

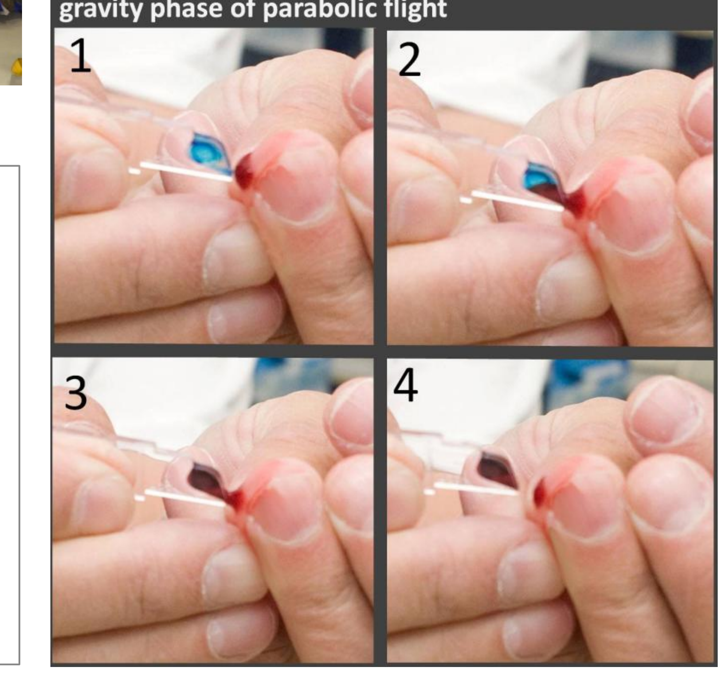


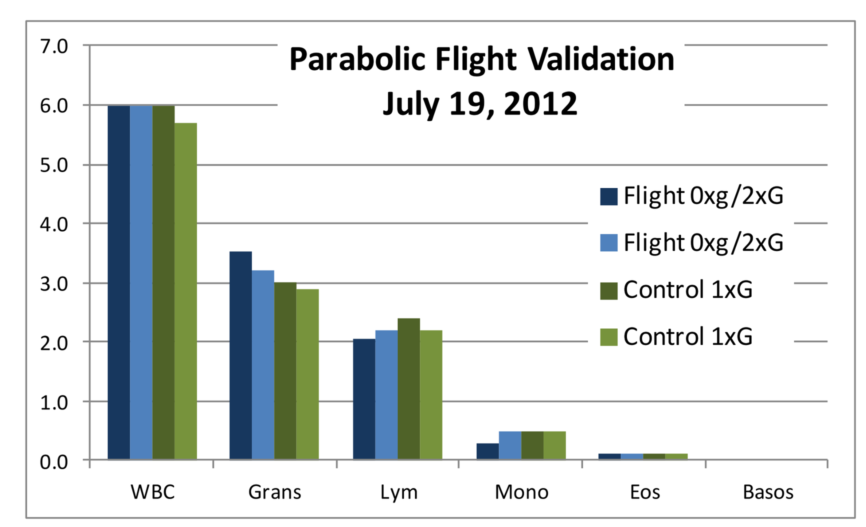


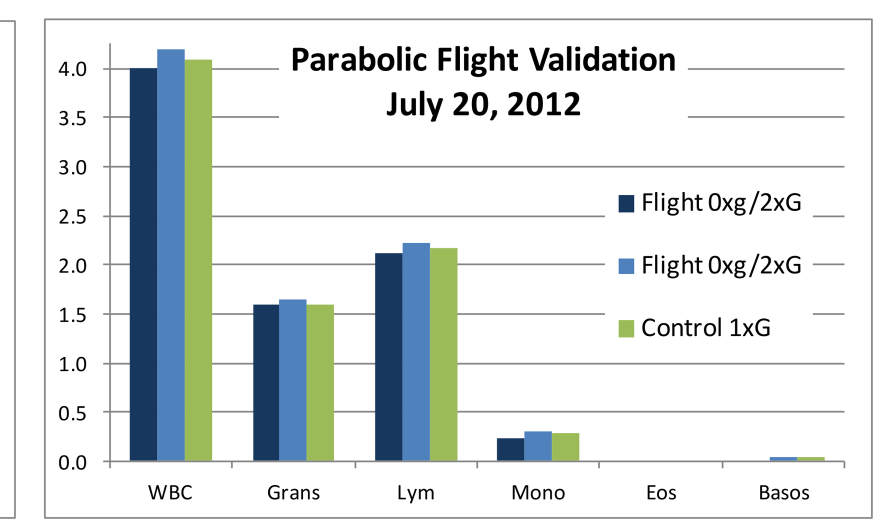
REDUCED GRAVITY VALIDATION



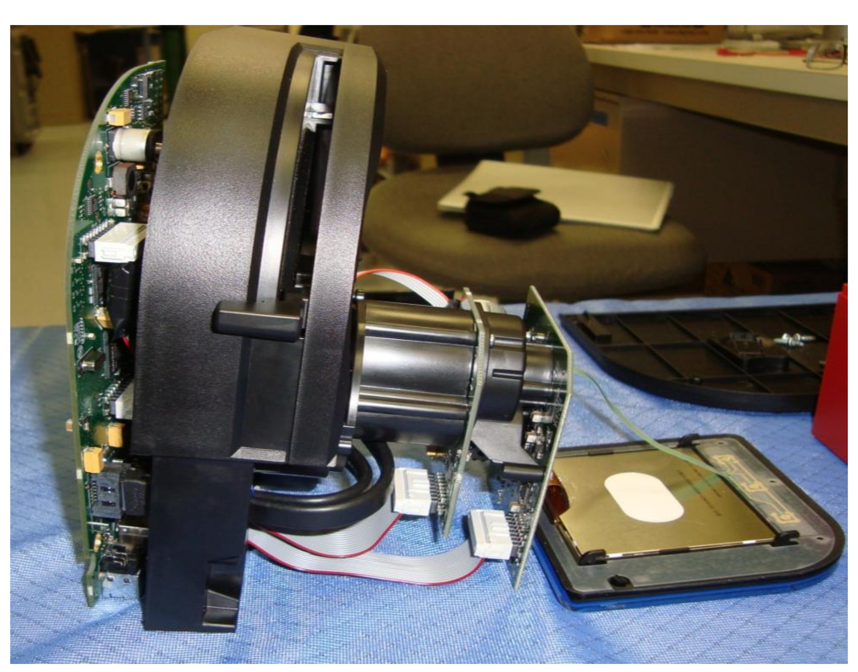
Fingerstick blood sample collection during zero-gravity phase of parabolic flight



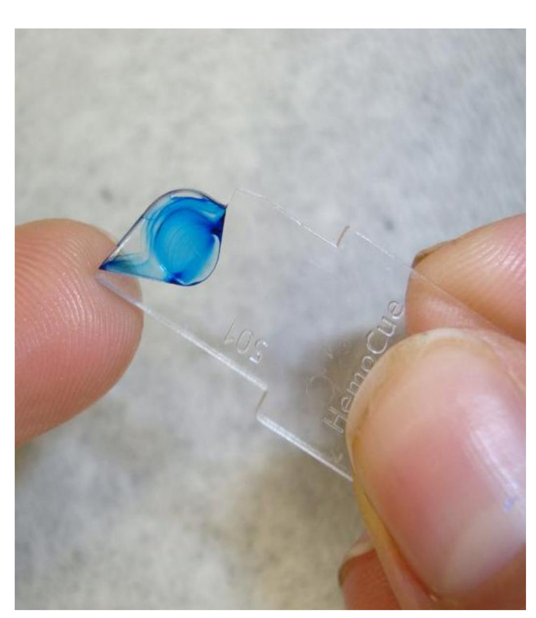


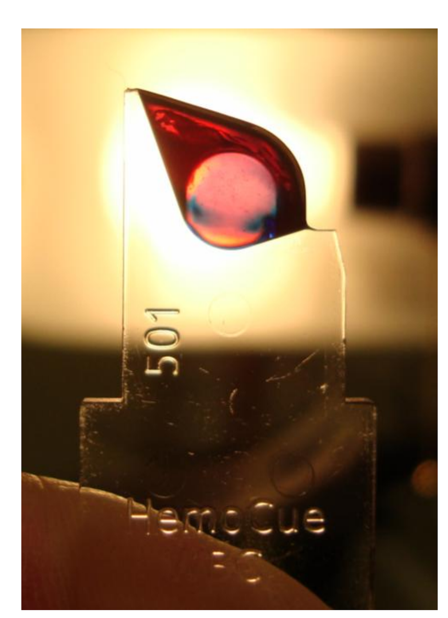


INSTRUMENT



SAMPLING





INFUSION POTENTIAL

This technology has been proposed for on-orbit demonstration by the Human Research Program. There is currently no other mature technology that can provide hematology data during spaceflight. This is primarily a spaceflight-enabling medical technology.

NASA TECHNOLOGY AREA ROADMAP

NASA OCT Grand Challenge Addressed: Space Technology Grand Challenge Mapping - Expand Human Presence in Space: Space Health and Medicine. NASA Technology Area Roadmap Addressed: Space Technology Roadmap Mapping: 2.3 Human Health and Performance Technology: Portable In-flight biosample analysis (ref: TA06 pg 15). JSC Topic and Subtopic(s) Technology Addressed: Area 2.1 and 2.3. The proposed device would directly 'provide healthcare capability for exploration missions" by allowing a capability to monitor hematological parameters during spaceflight.

***Author Contact:** 281-483-7061; brian.crucian-1@nasa.gov

CHRISTUS. ST. JOHN Hospital

Project Start TRL: 4 Current TRL: 6

Appendix C

JSC FY'12 CIF Support Project Details
Innovation Charge Account

Electrospray Ionization for Water Monitoring

William T. Wallace and Thomas F. Limero / SF2 / Wyle Science, Technology, and Engineering Group

Contact Info: william.wallace-1@nasa.gov / 281-483-2846

PROJECT OVERVIEW

- Current methods for monitoring the water used on the ISS rely heavily on ground analysis of archival samples. Air monitors presently on board the ISS could be used for trace analysis of the water samples.
- Electrospray ionization (ESI) is a powerful and widely used ionization technique for analysis of biomolecules in solution and provides a potential means for introducing water into the current monitors.

RELEVANCE/ VALUE TO NASA

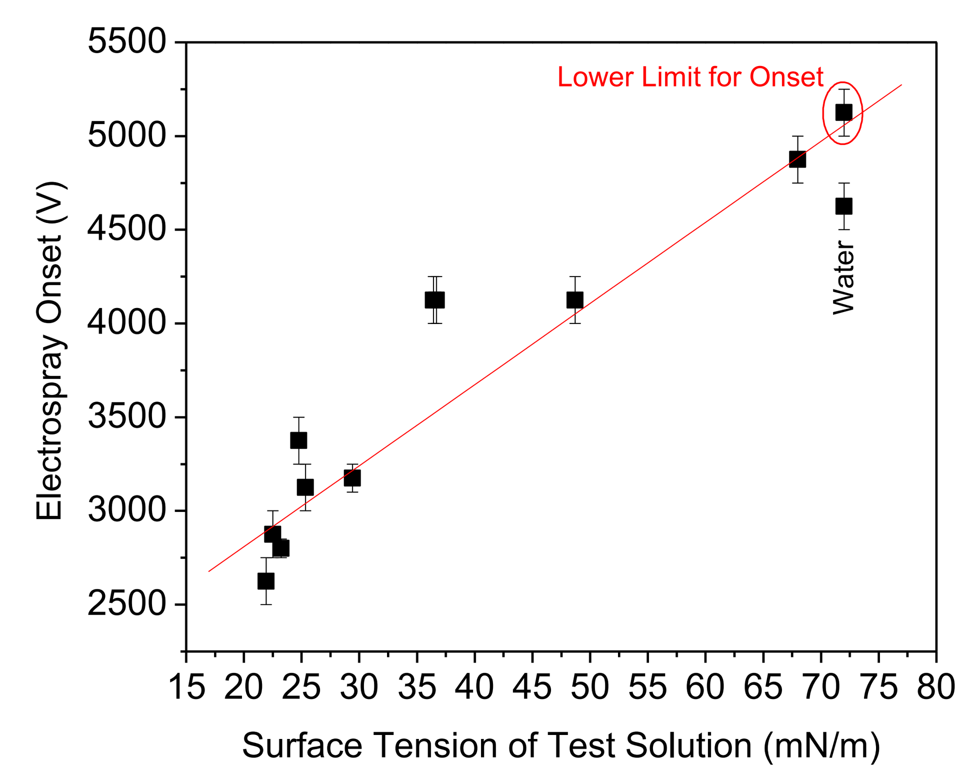
- The ability to analyze water samples (and possibility biological fluids) on orbit will limit/eliminate the need for sample return.

OBJECTIVES & OUTCOMES

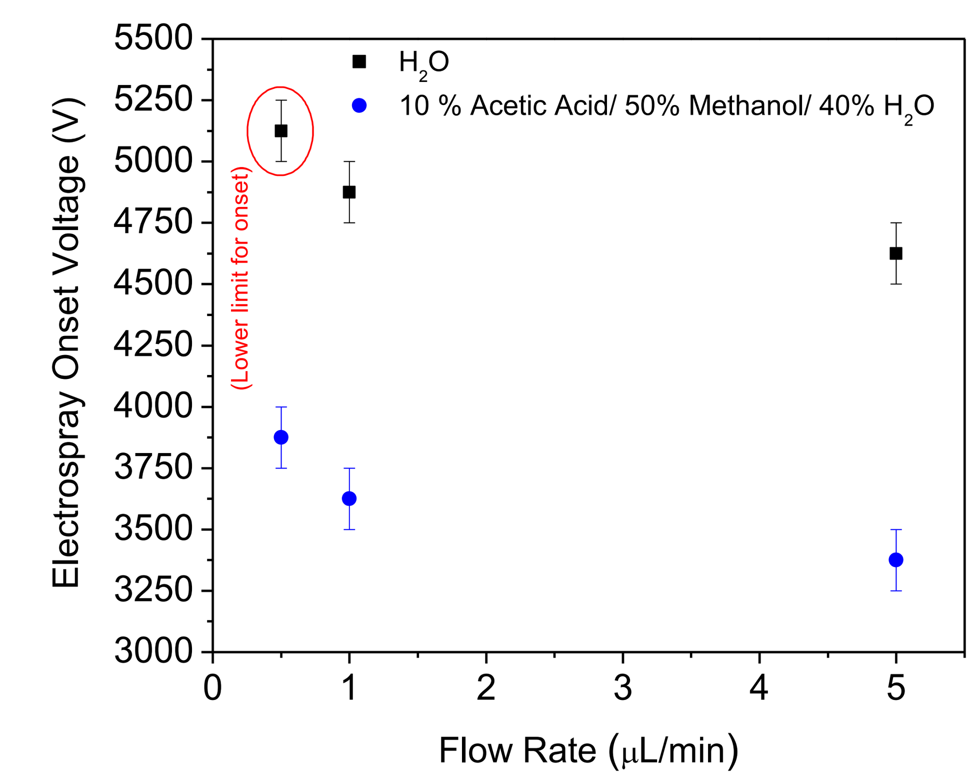
- The objective of this project is to determine the optimal parameters necessary for electrospray formation.
- The product of this work is a report detailing the necessary conditions to use ISS water for electrospray.

INFUSION POTENTIAL

- The infusion potential of electrospray lies in its potential to be interfaced with types of instrumentation previously or currently used on ISS. These include differential mobility spectrometry (Air Quality Monitor) or ion mobility spectrometry (Volatile Organic Analyzer). The ability to analyze water samples in real time makes ESI a potential ionization source for future exploration missions.



Effect of surface tension on ESI formation



Effect of flow rate on ESI formation

NASA TECHNOLOGY AREA ROADMAP

- This project is relevant to TA-06 Human Health, Life Support, and Habitation Systems, aligning with 6.4 Environmental Monitoring, Safety, and Emergency Response.

PROJECT DEVELOPMENT SCHEDULE

Project: Electrospray Ionization for Water Monitoring							
Start Date: Jan 3, 2012 End Date: Apr 20, 2012							
January 2012		February 2012		March 2012		April 2012	
Kick-off							
	Ordering and Construction of ESI						
				Testing of ESI with Camera			
							Report

Project Start TRL (1-9): 2
Current TRL (1-9): 3

Testbed for Aerothermal Test Technique Development

A. BRANDON OLIVER & JESSIE POWELL

Applied Aeroscience and CFD Branch (EG3)

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PROJECT OVERVIEW

- Assess the feasibility of developing a low-cost, small-footprint wind tunnel facility for testing innovative techniques for obtaining aeroheating data

RELEVANCE/ VALUE TO NASA

- The cost of aerothermal testing can be considerably reduced if advanced data reduction techniques can be developed and verified

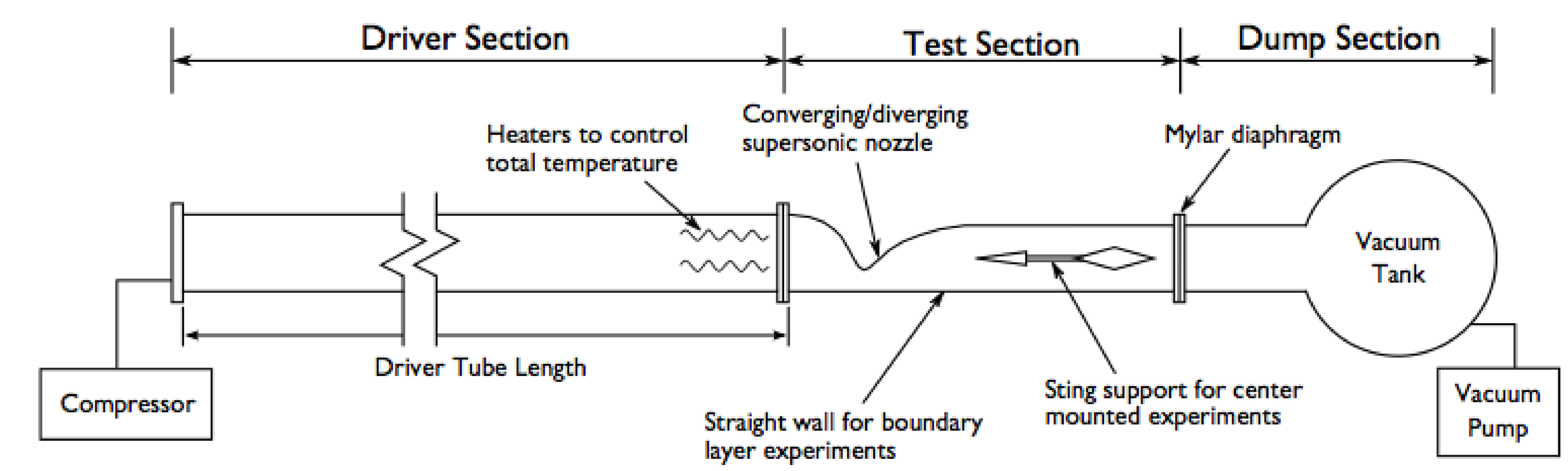
OBJECTIVES & OUTCOMES

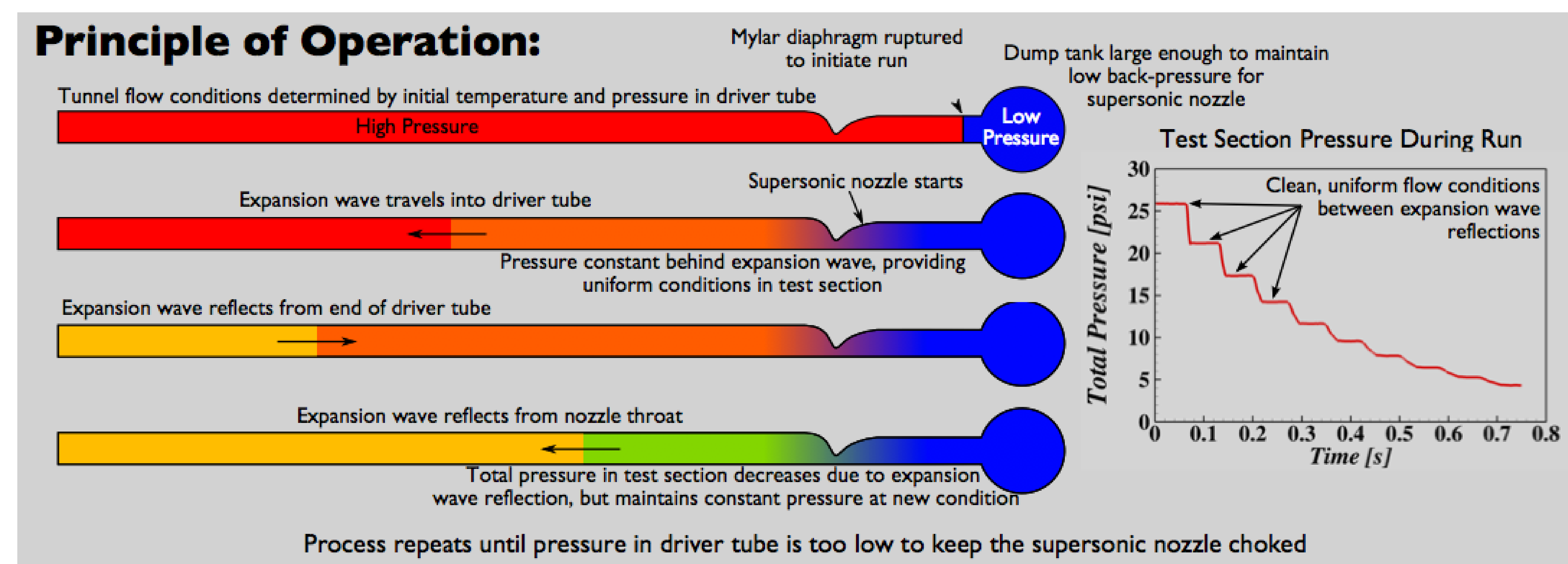
- Demonstrated that, contrary to analysis prediction, a reduced footprint driver tube would not provide the necessary performance without additional design work
- Performed the major design work for a conventional Ludwieg tube facility

INFUSION POTENTIAL

- Conventional aerothermal testing instrumentation and techniques require highly specialized facilities which greatly increase the cost of new vehicle development. Developing novel and innovative testing techniques can open the door to cheaper and more common facilities. More testing data means better computational and analytical models, which will reduce the cost to projects like Orion for developing aerothermal environments.

Schematic of a Typical Ludwieg Tube:

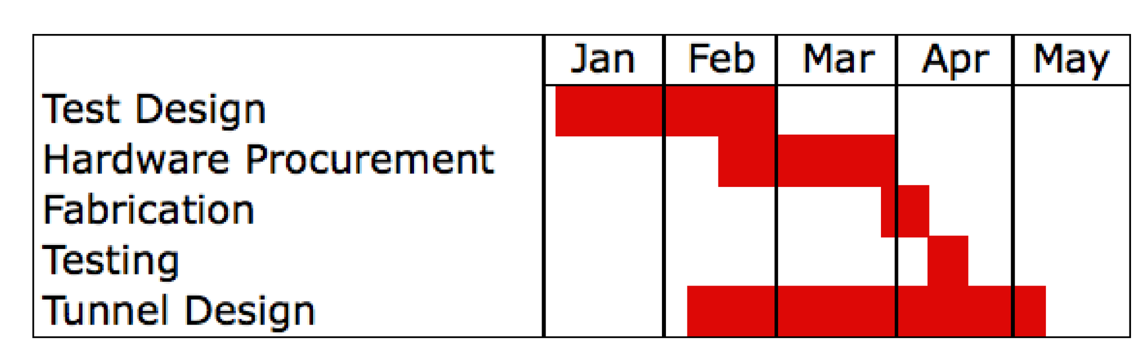




NASA TECHNOLOGY AREA ROADMAP

- Entry, Descent, & Landing Systems
  - Improve modeling and simulation of aeroheating environments, reducing the cost of vehicle development

PROJECT DEVELOPMENT SCHEDULE



Project Start TRL (1-9): 2

Current TRL (1-9): 3

Rocket Fuel Synthesis by Fischer-Tropsch Process

PROJECT MANAGEMENT

Rama kumar Allada Ph.D, EC2 (ESCG)
281-461-5403/rama.allada@escg.jacobs.com

PROJECT OVERVIEW

- Sabatier has been developed to supply fuel during Mars missions by converting Martian atmosphere to methane. However, methane rocket technology is still under development, and current propulsion systems rely on liquid hydrocarbons.
- This study explores using fischer-tropsch to generate liquid hydrocarbon fuels for Mars return.

RELEVANCE/ VALUE TO NASA

- Gas-to-liquids (GTL) can produce kerosene (RP-1) that is compatible with current propulsion systems.
- Reduce the risks and costs associated with developing and certifying methane-engines. .

OBJECTIVES & OUTCOMES

- Assessed feasibility and process economics through models and detailed analysis.
- Provided a conceptual design of GTL fuel plant suitable for Mars exploration missions.

INFUSION POTENTIAL

- Specifically geared towards Mars exploration and can be inserted through ISRU programs.
- Commercially used to produce transportation fuels from natural gas. USAF is also looking at fischer-tropsch as an alternative to petroleum based jet fuel.

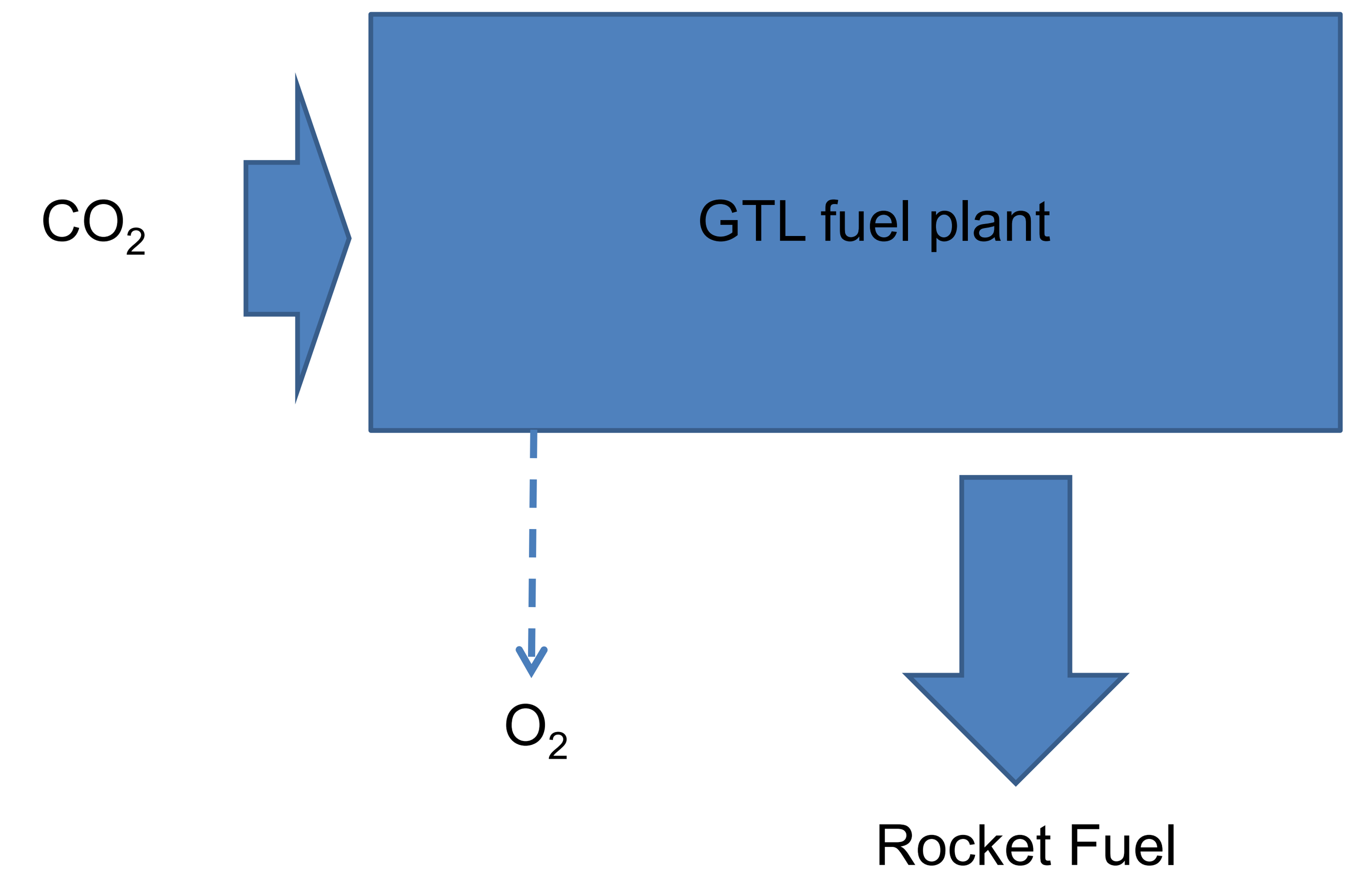
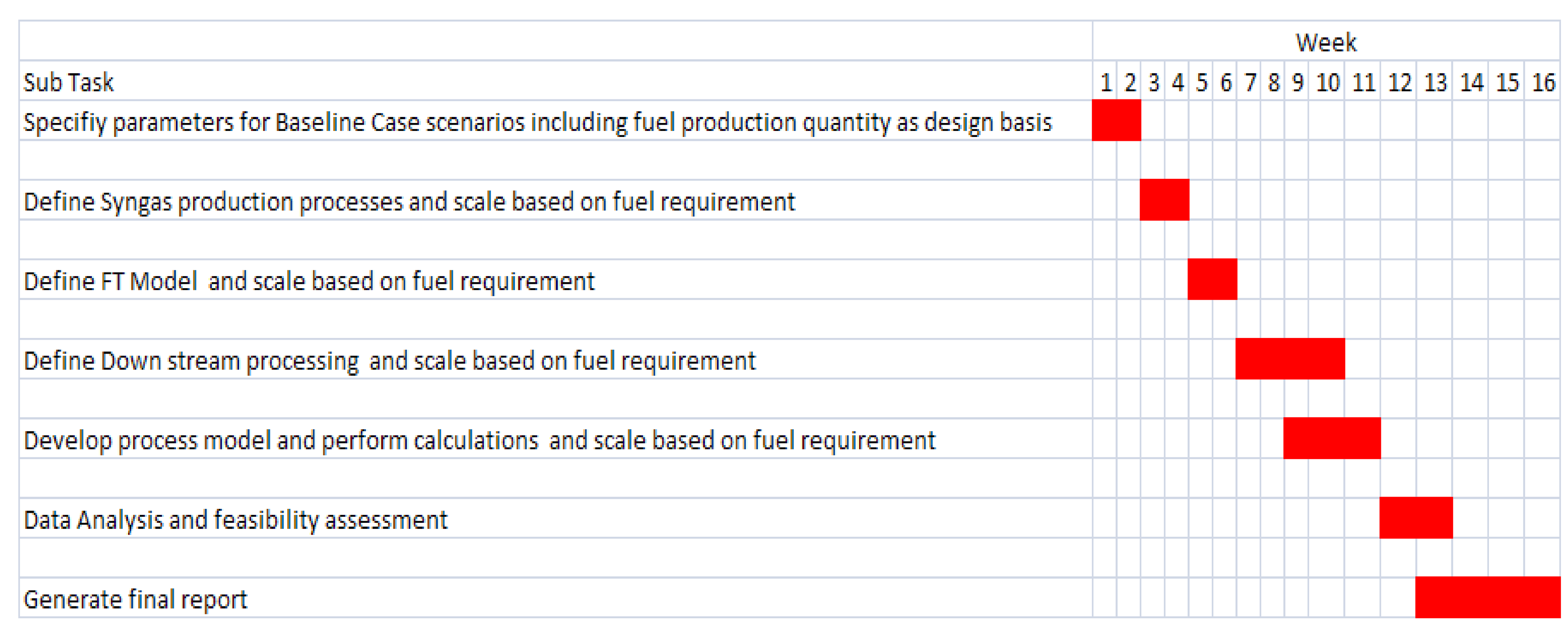


Figure 1. Conceptual Design of ISRU plant for Mars RP-1 production. The process produces RP1 along with some oxygen.. Technology is currently under review by NASA Tech Transfer office (MSC-25291-1).

NASA TECHNOLOGY AREA ROADMAP

•The focus of this project aligns to the TA07 roadmap with specific applicability to ISRU – Consumables Production

PROJECT DEVELOPMENT SCHEDULE



Project Start TRL (1-9): 1
Current TRL (1-9): 2

Modeling Limbless Locomotion Using ADAMS

PROJECT MANAGEMENT

Prashant S. Rao, Ph. D., Jacobs-Engineering and Science Contract Group
Tel: (281) 461-5808; Email: prashant.rao@escg.jacobs.com

PROJECT OVERVIEW

- This study explored the modeling and simulation of limbless locomotion and its application to the space program. Several algorithms were studied: serpentine motion, serpentine motion with sinusoidal lifting, concertina and burrowing.

RELEVANCE/ VALUE TO NASA

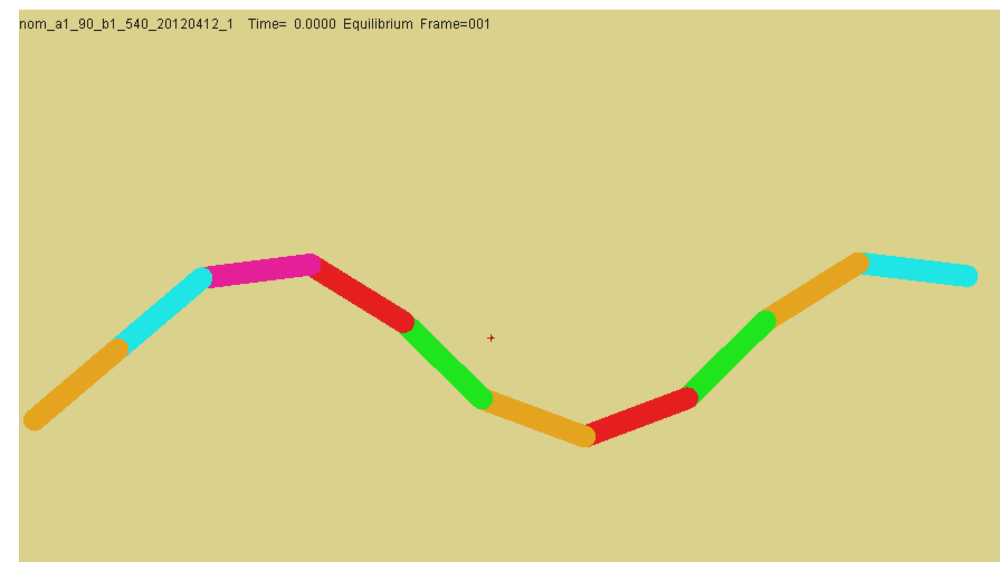
- Serpentine robots will be – stable, able to traverse varied terrain (rocky, soft soil, liquid, narrow passageways ...)
- Can be sealed against the environment.
- Can be used to anchor to soil / aggregates.

OBJECTIVES & OUTCOMES

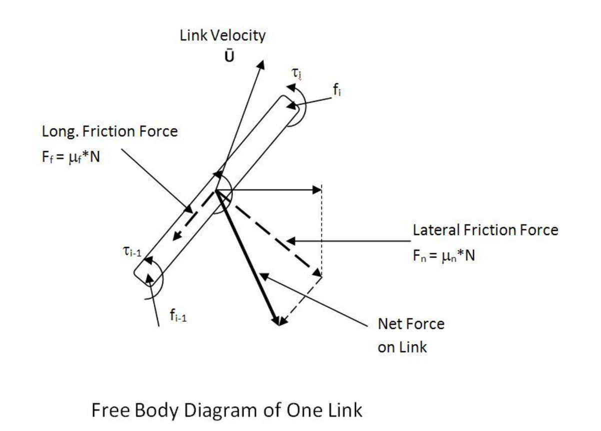
- Study how well ADAMS is suited for modeling limbless locomotion.
- Determine relationships between design parameters and performance.
- Correlate the ADAMS model with test data if avail..
- Investigated 3-link and 5-link &10-link models for serpentine motion, concertina motion, sinusoidal lifting, isotropic friction, simple burrowing model.
- Design of Experiments study to relate parameters to performance.
- Non-dim mechanical "efficiency" defined – correlation with Dist/Work – 88%

INFUSION POTENTIAL

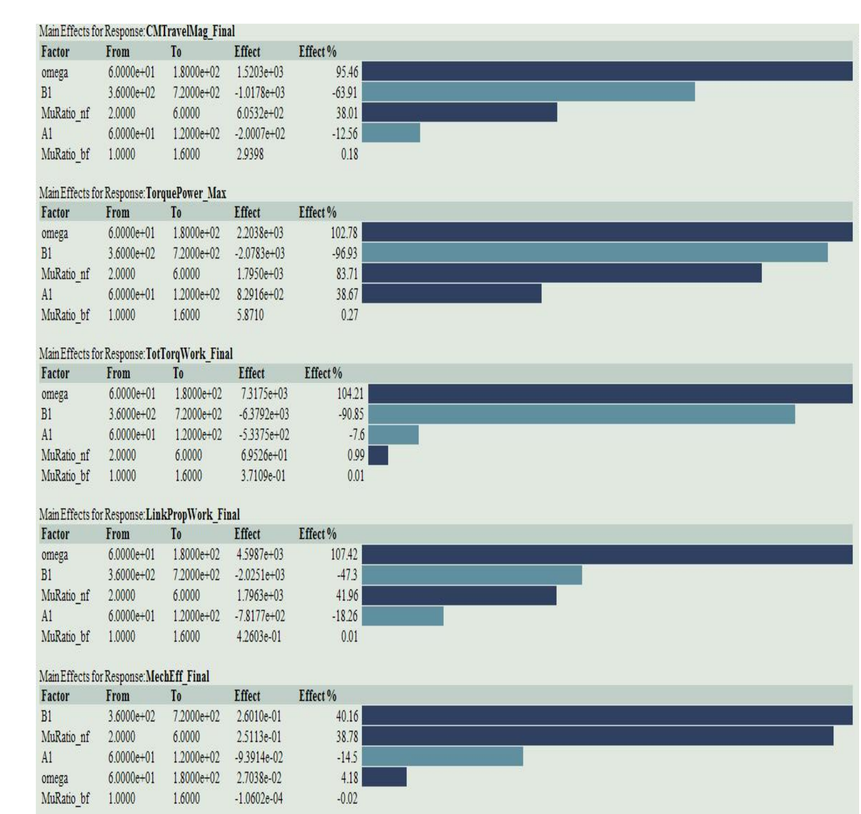
- Anchoring to asteroids identified as a top challenge for both robotic and manned missions to asteroids (TA04). Serpentine robots may be able to burrow into loose aggregate/soft soils and act as anchors. Serpentine robots will be particularly useful on missions to bodies with loose soils or with solid and liquid surfaces like Titan.



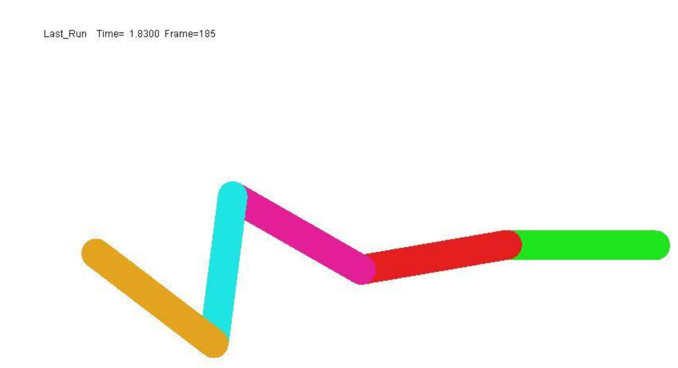
Ten-link ADAMS Model



Free-body Diagram



DOE Results



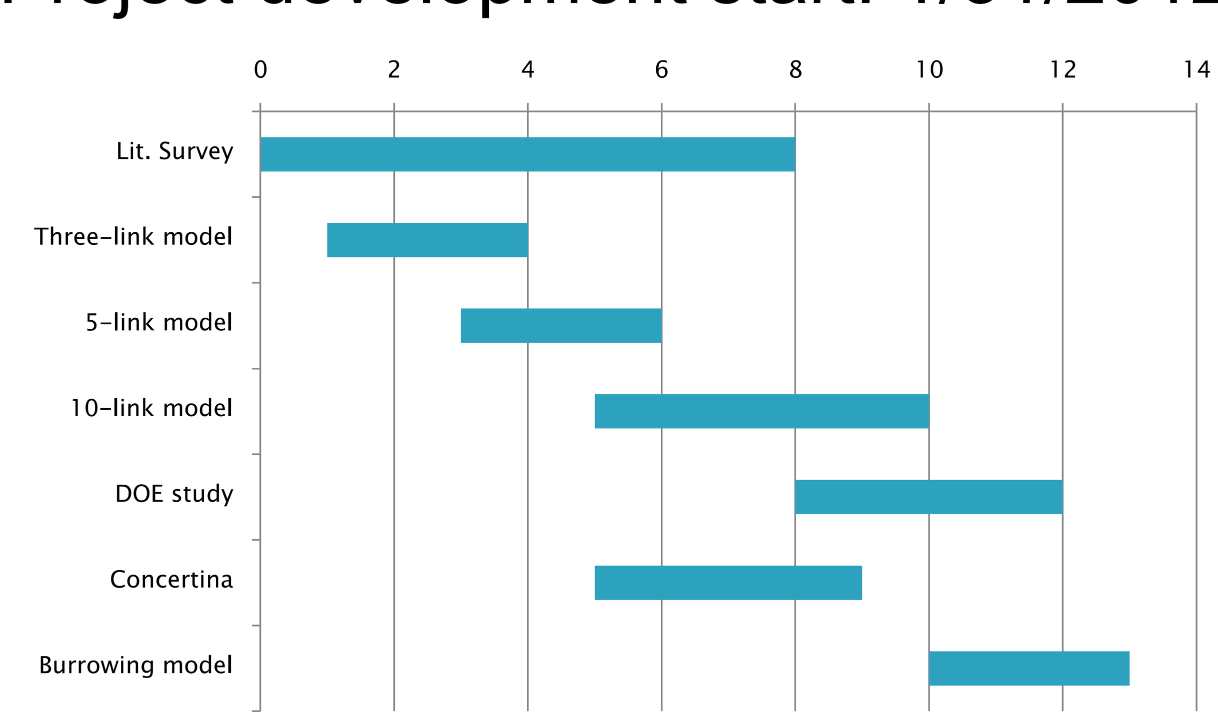
Concertina

NASA TECHNOLOGY AREA ROADMAP

- **TA04 Robotics:** 4.2 Mobility (Extreme Terrain & Sub-surface); 4.3 Manipulation Technology/ NEA Human Mission
- **TA07 Human Exploration Destination Systems:** 7.1 ISRU; 7.6 Modeling, Simulation & Destination Characterization

PROJECT DEVELOPMENT SCHEDULE

- Project development start: 1/31/2012



Project Start TRL (1-9): 1
Current TRL (1-9): 1/2

Pitch Synchronous Segmentation of Speech Signals

PROJECT MANAGEMENT

Anikó Sándor, Ph.D. & Kritina L. Holden, Ph.D., Human Factors and Habitability Branch, SF3

281-483-9726, Aniko.sandor-1@nasa.gov, 281-483-8829, Kritina.l.holden@nasa.gov

PROJECT OVERVIEW

- Pitch synchronous segmentation (PSS) is an algorithm that allows speech to be accelerated without a negative impact to intelligibility. At NASA it could be used to improve flight controller and crew communications.

RELEVANCE/ VALUE TO NASA

- Application of PSS and acceleration to speech channels could decrease workload and increase efficiency of crewmembers and flight controllers who have to monitor single or multiple channels of speech communication during missions.

OBJECTIVES & OUTCOMES

Objectives

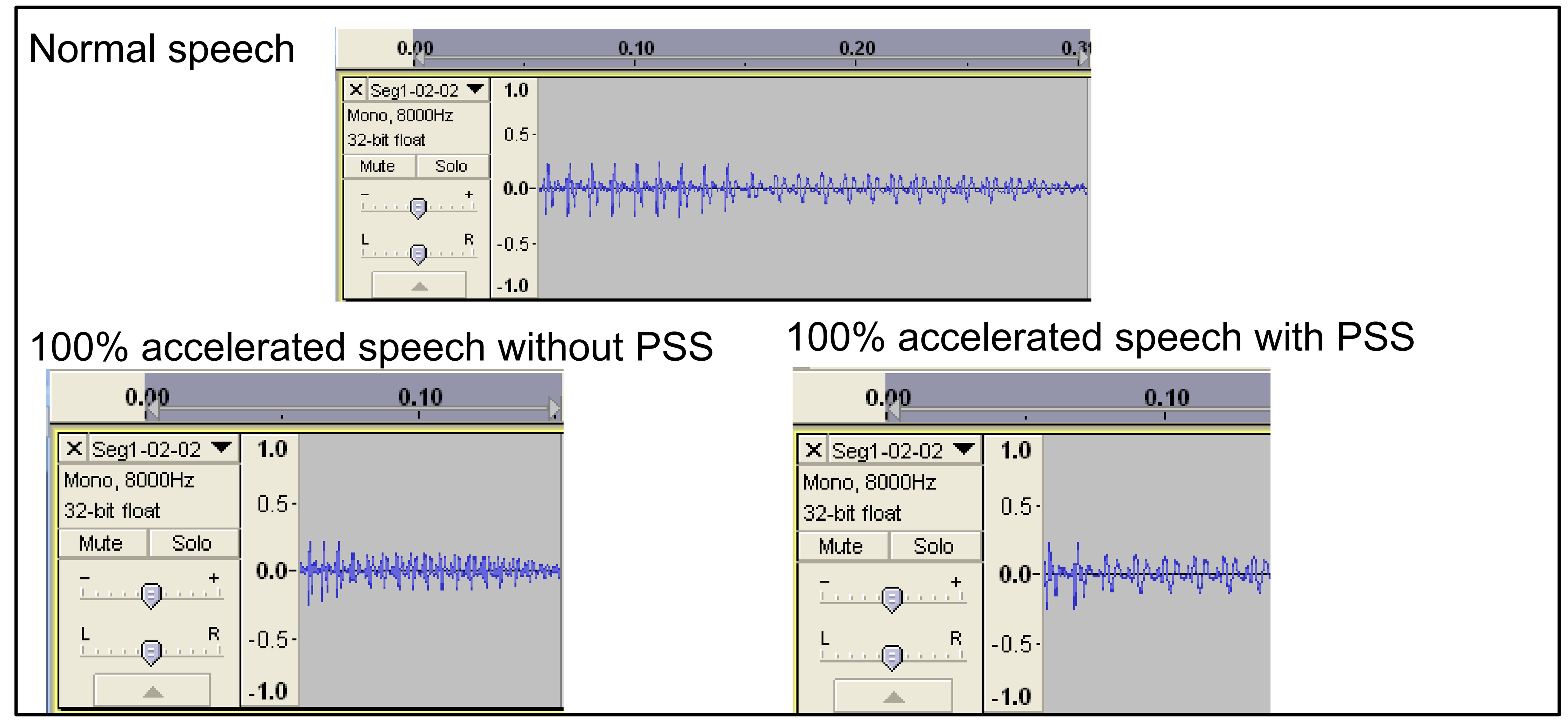
- Collaborate with the Naval Research Institute (PSS patent owners), and the University of Houston Clear Lake (also currently investigating PSS).
- Complete a feasibility assessment by conducting subject matter expert interviews regarding the potential benefits of PSS
- Create and evaluate demonstrations of processed sounds with crew and MOD representatives

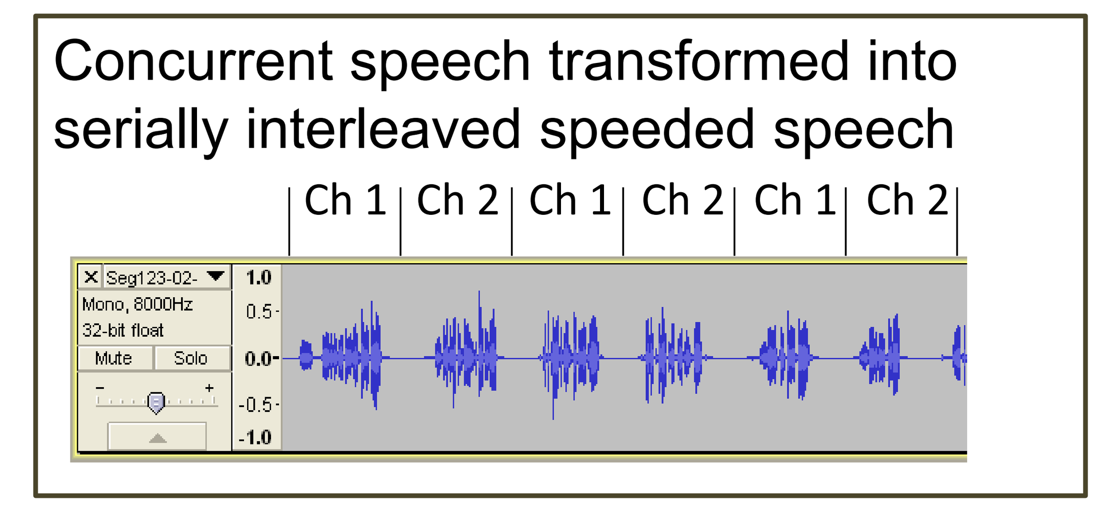
Outcomes

- Two key application areas were identified:
  - Immediate accelerated playback of ground control communication with crew (to confirm dialog that was missed)
  - Accelerated playback of recordings for troubleshooting anomalies
- Use of PSS for live, concurrent speech requires further research to determine the cost and benefits.

INFUSION POTENTIAL

- With further investigation and development, PSS and accelerated speech could be applied to current MOD operations, analogs (e.g., DSH), and ISS operations.
- This technology could also be applied in the air traffic control environment, or other control center environments that rely heavily on communication.





NASA TECHNOLOGY AREA ROADMAP

- TA07 – Human Exploration Destination Systems section / Mission Operations and Safety subsection

PROJECT DEVELOPMENT SCHEDULE

Weeks 1 - 8

- Meetings with US NRL and UHCL on prior and current PSS work
- Tour of Digital Voice Intercom System (DVIS) facility at Wyle

Weeks 9 - 16

- Researched ISS and Shuttle sound recordings in the NASA audio collection; sounds processed at NRL
- Meetings and evaluation with crew, flight controllers, crew representatives

Project Start TRL (1-9): 2
Current TRL (1-9): 2

Augmented Reality to Enhance Crew Medical Training

PROJECT MANAGEMENT

Lui Wang / ER; William Buras / SA-Tietronix; Yoshino Sugita / SA-Wyle

281-483-8074 & lui.wang-1@nasa.gov . Collaboration: David Martin/SK2 Ultrasound Instructor; David Ham/SA Ultrasound System Integrator; Victor Hust/SK

Project Overview

Augmented Reality (AR) tools for medical training can provide real-time, in situ guidance, reducing training burden and improving crew proficiency. Recent advances in AR technology simultaneously reduce the technology's footprint while increasing effectiveness of training and real-time support.

Relevance / Value to NASA

NASA consistently searches for efficiencies in astronaut training. Our portable, intuitive tool will:

- Save crew training time while increasing proficiency
- Decrease need for ground support and enable on-orbit refresher training
- Can be expanded to additional training procedures

Objectives & Outcomes

The objectives were to:

- Identify the medical training procedure that would benefit from AR support
- Design the best hardware configuration for an AR prototype

The outcomes of this pilot project were:

- Identified medical training procedure for AR tool development (Ultrasound).
- Identified a series of tool features that would significantly improve training and operational support:
  - Visualize current and ideal image in visual field
  - 3D guidance of transducer position refinement
- Identified potential collaboration and bench-marking opportunities

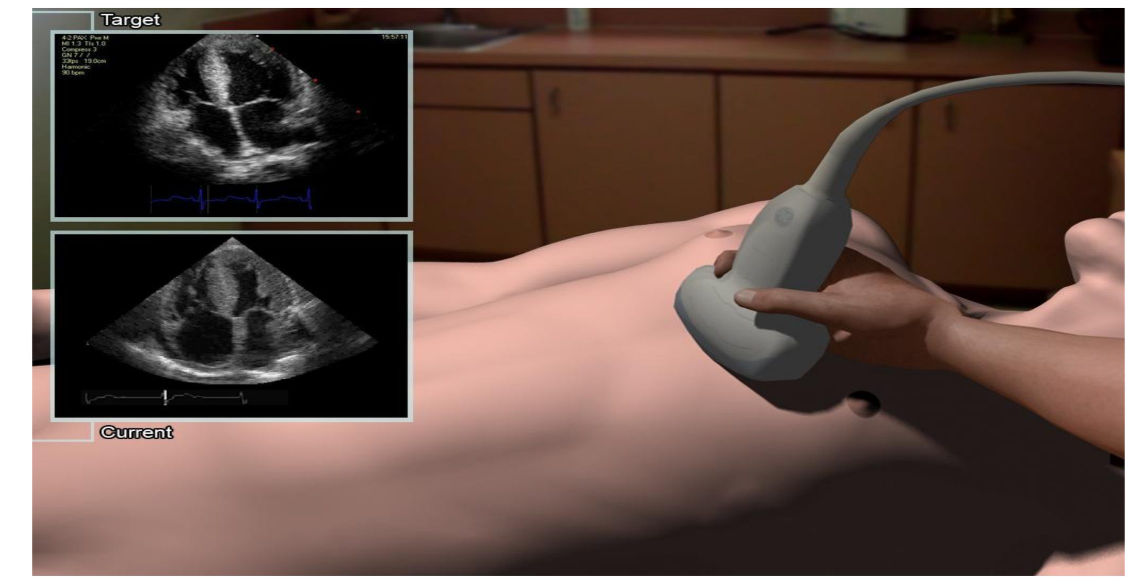
Infusion Potential

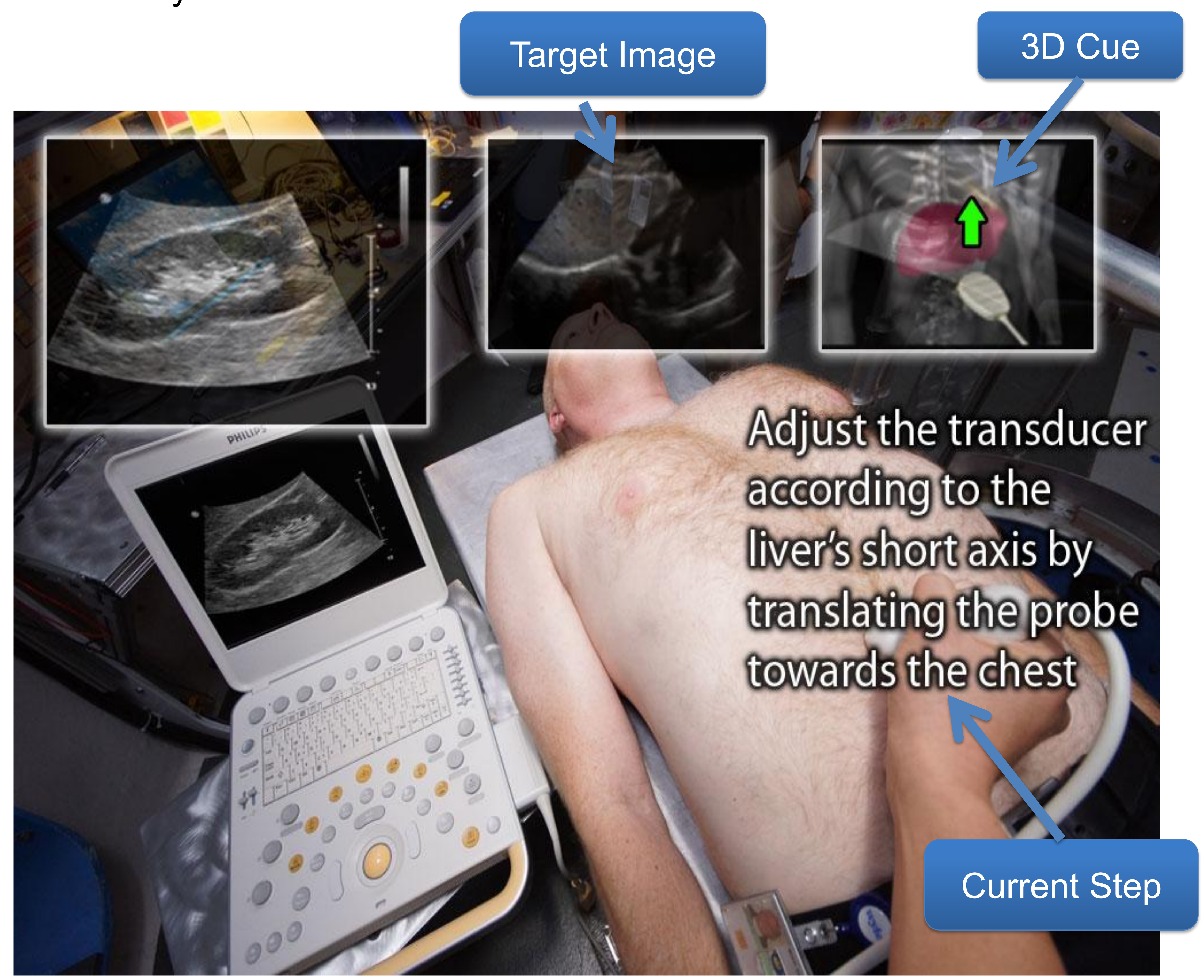
The technology will be matured and infused through series of demonstration with increasing fidelity from ISS training facility to on-orbit ISS DTO demonstrations. The ISS Program is striving to minimize crew time spent on training and reliance on ground support for operations.

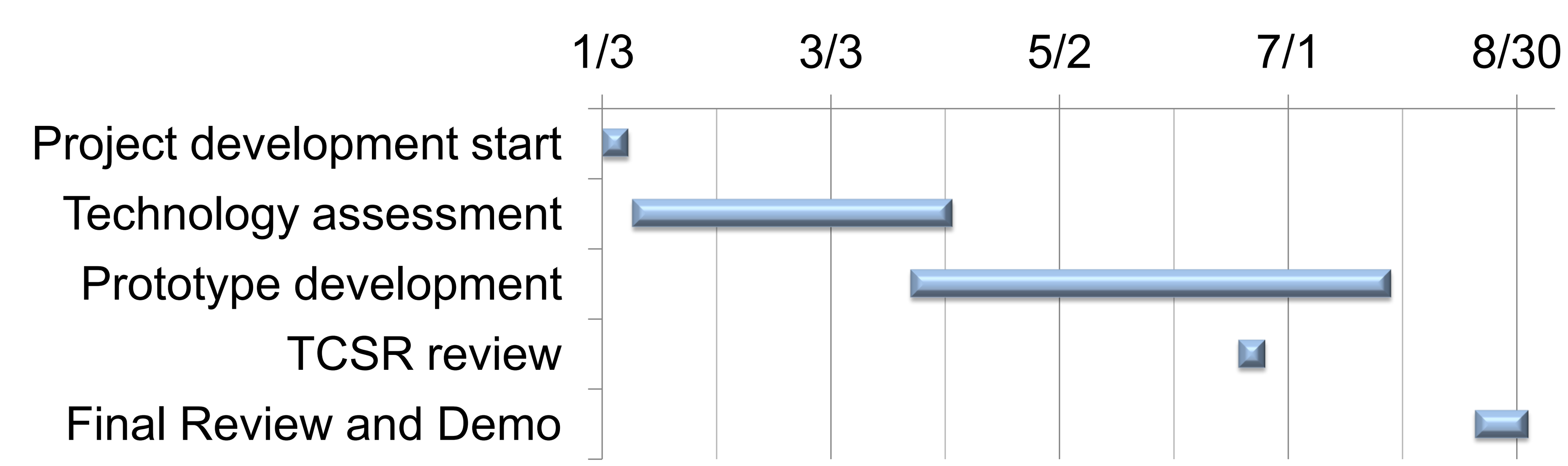
NASA Technology Area Roadmap

- 4.0/4.4 Human Systems Interaction (Just-in-Time human performance support),
- 4.0/4.5 Autonomy (enable crew autonomous operation and reduce dependency on ground support),
- 6.0/6.3 Human Health and Performance (enhance situational awareness, reduce cognitive overload),
- 7.0/7.5 Mission Operations & Safety (reduce human error, improve operational efficiency).

Sony HMZ-T1







Project Start TRL: 2

Finish TRL : 3

Parachute Cord Tension Sensor

Satish Reddy, ESCG, 281-461-5533, Satish.Reddy@escg.jacobs.com

Robert Wilkes, Jr., ESCG, 281-461-5216, Robert.WilkesJr@escg.jacobs.com

PROJECT OVERVIEW

- A small, simple, sensor using pressure film technology was developed to measure the Orion main parachute suspension line tension during deployment. Multiple design concepts were investigated and down selected to one that provided linear, low scatter measurements. Static and dynamic validation tests were performed that provided calibration.

RELEVANCE/ VALUE TO NASA

- This invention allows accurate measurement of parachute cord loads that were previously estimated using analysis techniques. This will allow elimination of uncertainty load factors and better sizing of parachute hardware.

OBJECTIVES & OUTCOMES

- 4 calibrated sensors delivered for a Orion CPAS drop test in the Yuma desert.

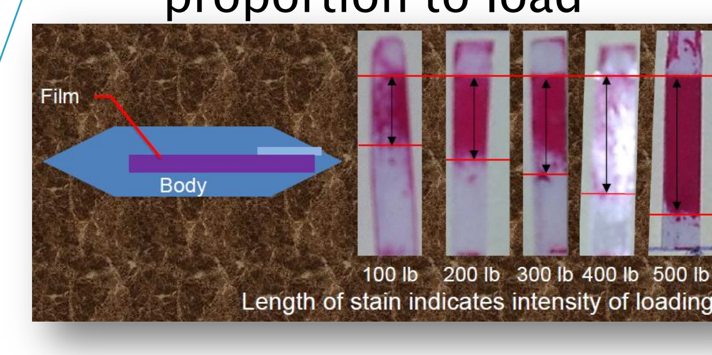
INFUSION POTENTIAL

- Presented to the Orion CPAS (the parachute system for the Orion/MPCV vehicle) program.
- Expected to be manifested to fly on a November 2012 drop test.

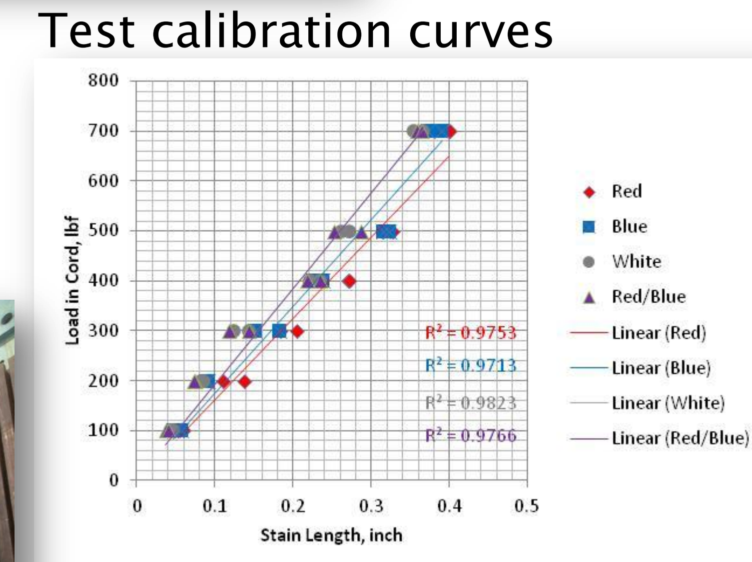
Down selected to

Inserted into Kevlar cord

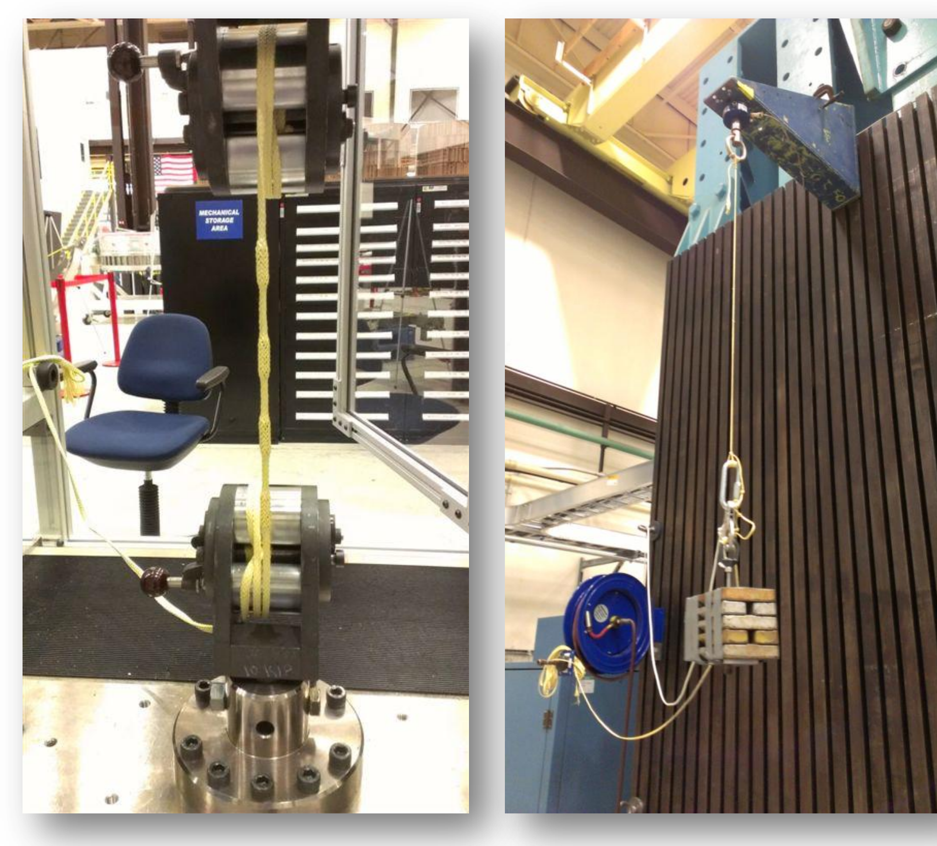
Film stain length in proportion to load



Test calibration curves



Static and Dynamic Testing in ES division's Structures Test Lab



Flight test

NASA TECHNOLOGY AREA ROADMAP

- TA-09 – Entry, Descent and Landing

PROJECT DEVELOPMENT SCHEDULE

- Project development start: 1/20/2012
- Design/Analysis complete: 3/23/2012
- Prototype manufacturing: 4/6/2012
- Validation testing completed: 4/20/2012
- ICA funded work completed: 4/19/2012

- Jacobs Technology funded final design completed: 6/10/2012
- ES division funded calibration test completed: 6/20/2012

Project Start TRL: 1
Current TRL: 6

Unmanned Microgravity Flight Program

P.I.s - J. Fox & M. Hart

Goal/Innovation: Microgravity experiments between 5 & 15 seconds require flight on a manned full-scale aircraft. Small micro-G parabolic experiments could be flown on an unmanned jet aircraft.

Unmanned aircraft flights can be scheduled faster, executed faster, turned around and re-flown faster and for a lower price than a full-scale manned aircraft.

Aircraft
- Troybuilt "DV8R" platform
- Wingspan: 83"
- Length: 87"
- Weight: 22 lbs dry
- Design thrust: 22-30 lbs
-Heavy duty retractable gear with brakes
- Payload Capacity: ~ 8 lbs
- Power plant: Kingtech K170-E gas turbine
    - ~40 lbs thrust
    - Idle ~ 34,000 rpm
    - Max ~ 123,000 rpm
    - Weight: 3.5 lbs.
    - EGT: 700*C
    - 25 hrs between servicing

-Cost > $8 K
-URL: http://www.youtube.com/watch?v=JCmiE7zNGTs

Accomplishments / Milestones

- 6/04 - Project development start
  - Met with JSC RC club, NASA zero-g pilots, micro-g program lead
  - Walkdown of full-scale Zero-G aircraft
- 7/08 - First part ordered
- 7/28 - Aircraft delivery
  - Aircraft assembled, modified, & tested in 3 weeks
- 8/18 - Payload completed
- 8/21 - First engine test
- 8/30 - Payload test on full-scale micro-g plane
- 8/31 - Final review or report or demo
- 9/30 – Est. Project development completed

Future Prospects

- Begin ground handling test trials end of Jan'12
- Scheduling future payload flight experiments
- Begin Autopilot test trials with funding allocation
- Begin negotiations with NASA Aircraft Ops & obtain flight certification expected late FY'12 – Q2

Non-Powered Spectrophotometry For Lighting

PROJECT MANAGEMENT

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Jim Maida, Organization: SF3
281-483-1113, james.c.maida@nasa.gov

PROJECT OVERVIEW

- This project researches the concept of documenting light spectra but without the use of a powered spectrophotometer.
- The premise is that an optical solution is sufficient to document spectra for light sources such as those on ISS.

RELEVANCE/ VALUE TO NASA

- The spectrum of a light affects crew health. This solution does not require power or a calibration cycle.

OBJECTIVES & OUTCOMES

- Person must be able to distinguish unique spectra using spectroscope alone.
- Unique spectra are discernable to the naked eye.
- A camera can be put up to the viewport of a spectroscope to archive and document what the user sees.

INFUSION POTENTIAL

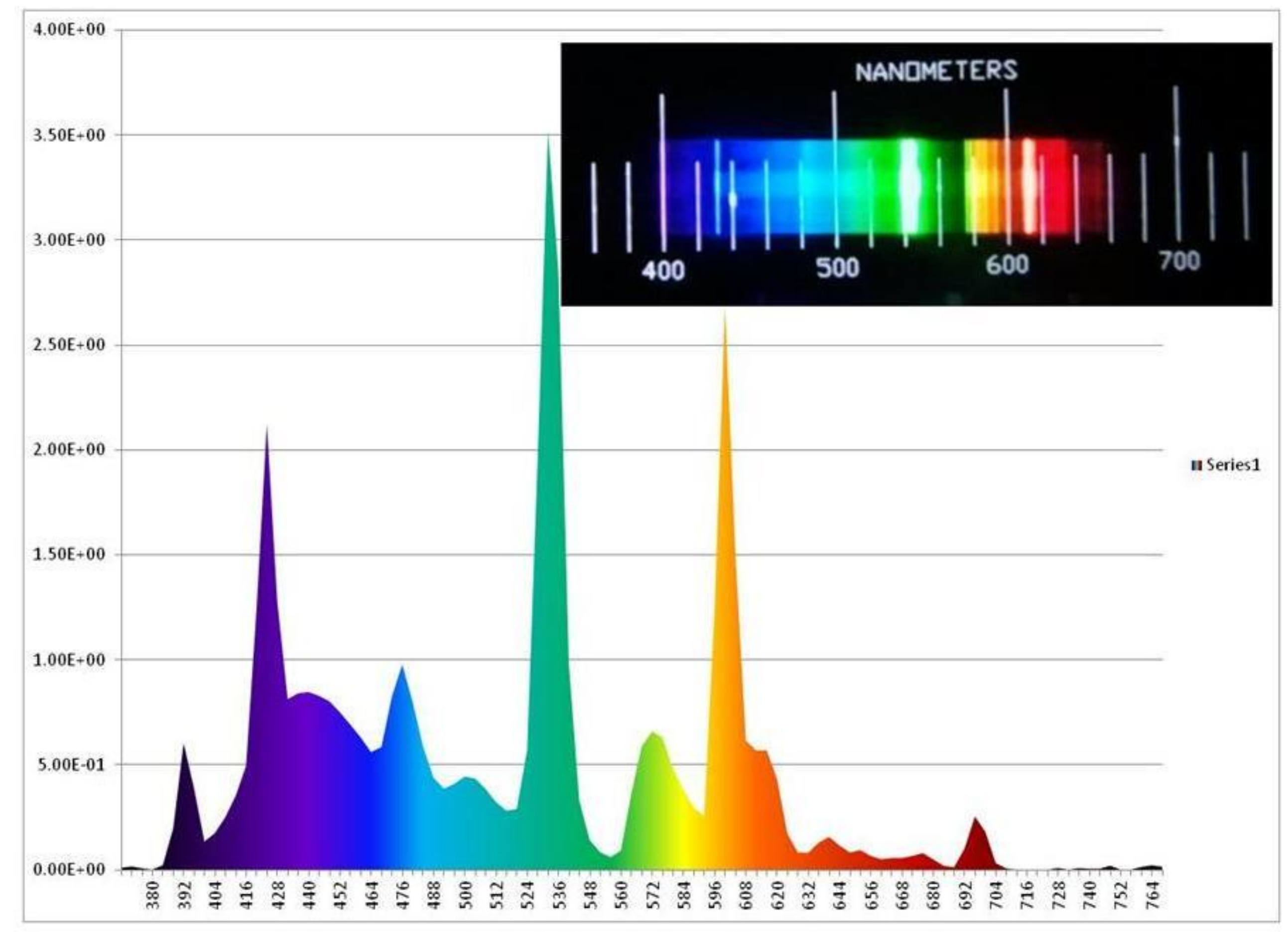
- The results from this project show that simple optical devices that use optics alone (diffraction gratings, prisms, lenses) can be used to document the spectrum of light.
- The ISS program needs a simple device to monitor lighting that has spectral performance criteria.
- Other applications that have spectral requirements can use this method.

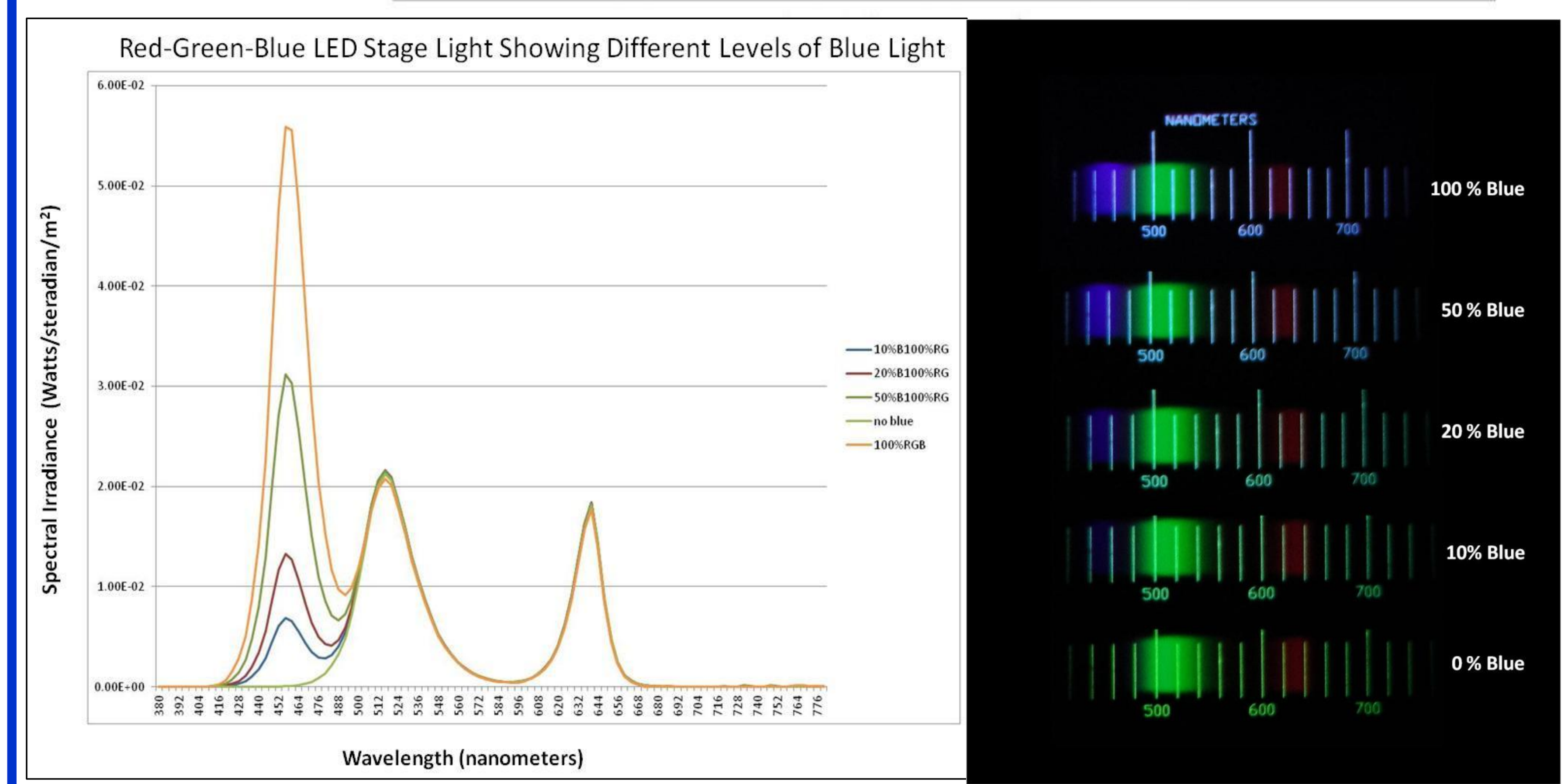
This chart shows the comparison of an optical image from a spectroscope and measured data from a calibrated spectrophotometer.

A spectroscope is a simple optical device (diffraction gratings or prisms) to split visible light into its basic spectral components. The image can be seen through a viewport.

Spectrophotometers measure the spectral power of light, require calibration, and are delicate powered optical systems.

The comparison clearly shows that an observer using a spectroscope would be able to identify components of a light's spectrum and that it can track with calibrated measurements.

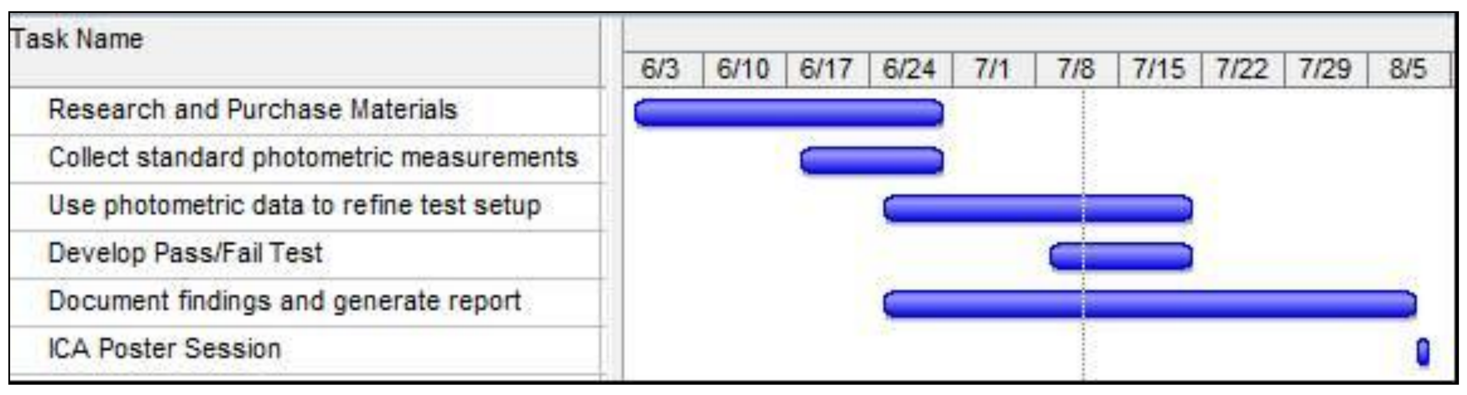




NASA TECHNOLOGY AREA ROADMAP

- TA3: Space Power & Energy Storage
- TA6: Human Health, Habitation, & Life Support Systems
- TA8: Science Instruments, Observatories, and Information Systems

PROJECT DEVELOPMENT SCHEDULE



Significant Milestones:

Purchase of hardware: Early June

Hardware Delivered/Test Start: Mid June

Lab verification of a sound concept: Late June

Detailed Testing and Documentation of Results: July

Project Start TRL (1-9): 2

Current TRL (1-9): 6

Coupled Human-Space Suit Mobility Testing

PROJECT MANAGEMENT

Lindsay Aitchison/EC5, lindsay.t.aitchison@nasa.gov, x38657
Ishita Jain/EC5, Brad Holschuh/Mass. Institute of Technology

PROJECT OVERVIEW

Current EVA mobility studies only allow for comparisons between how suits move when actuated by a human and how the human moves when unsuited. Small wireless inertial measurement units (IMUs) will be implemented to provide coupled data collection on human and suit motions during suited mobility evaluations.

RELEVANCE/ VALUE TO NASA

A better understanding human-suit interaction will allow engineers to identify space suit design parameters to optimize EVA performance and reduce injury risk associated with fit and posture issues that can be implemented in EMU upgrades and/or future exploration suit designs.

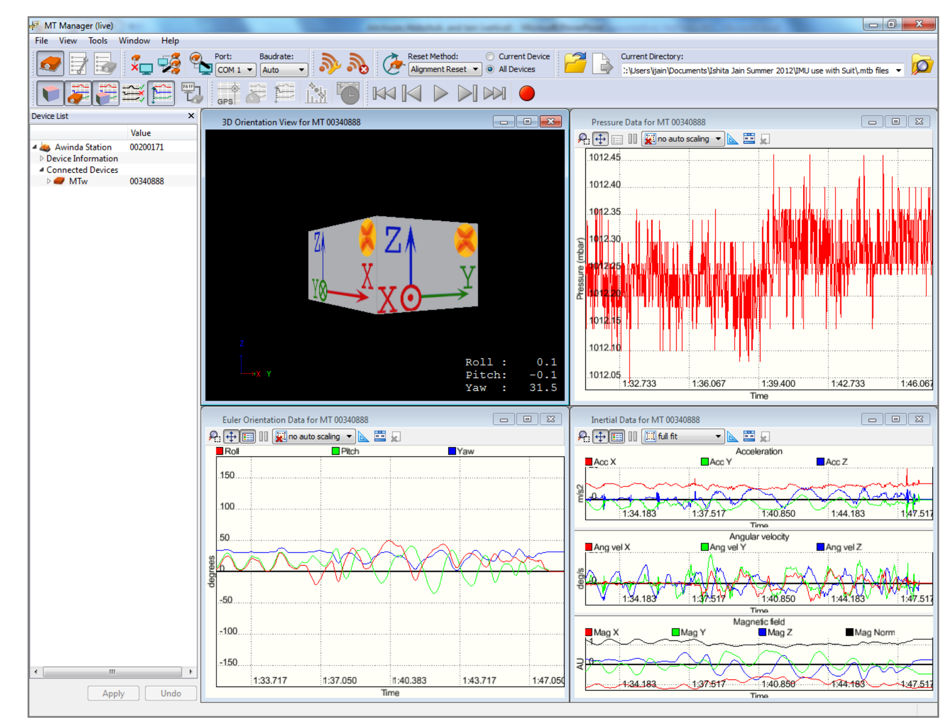
OBJECTIVES & OUTCOMES

•Purchased Xsens Technologies MTw development kit with six IMUs that can be coupled to Vicon MX for simultaneous motion capture
•Developed analysis code, sensor set-up, and protocol to measure joint motion in shirtsleeves condition
•Demonstrated minimal data loss when signal transmitted through pressurized space suit
•Forward work: Team with ABF to
  •Refine IMU analysis code using standard inverse kinematics approach similar to Vicon data analysis method
  •Collect simultaneous data on Vicon and MTw systems to compare human and suit elbow, knee, and torso joint ranges of motion

INFUSION POTENTIAL

Benchmarking of current suit prototypes using coupled motion capture techniques will increase understanding of current design capabilities and limitations to aid development of new exploration suit requirements for FY13.

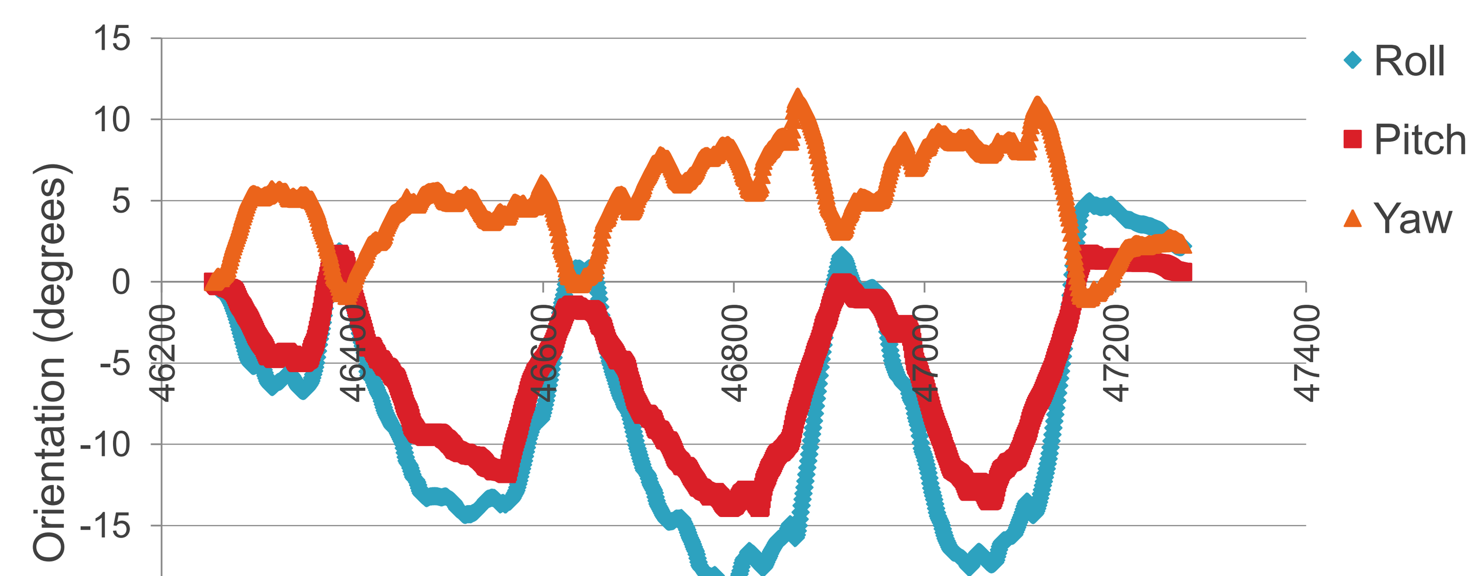
XSENS MTw IMU SYSTEM

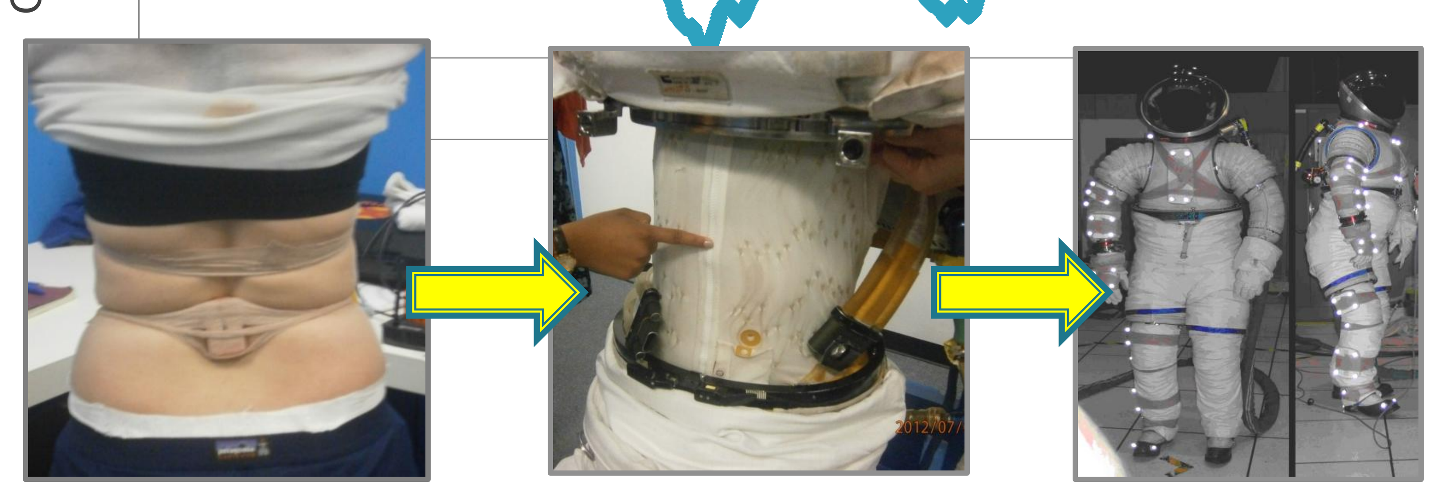


*Images taken from Xsens MTw User Manual

PRELIMINARY DATA

Pressurized EMU, Torso Flexion/Extension





NASA TECHNOLOGY AREA ROADMAP

This project supports the goals of Technology Area 06 EVA Systems Pressure Garment and Human Health and Performance HSI Tools/Methods.

PROJECT DEVELOPMENT SCHEDULE

	May	June	July	Aug	Sept
Purchase System					
Develop Analysis Code					
Code Validation					
Combined Vicon/IMU Testing					
Data Analysis and Reporting					

Project Start TRL (1-9): 2
Current TRL (1-9): 3

Foot Pedals for Spacecraft Manual Control

PROJECT MANAGEMENT

Stanley G. Love (CB and YA), Lee M. Morin (CB), and Mary McCabe (EV)
Phone: 281-244-2618 ; e-mail stanley.g.love@nasa.gov

PROJECT OVERVIEW

Fifty years ago, NASA decided that the cockpit controls in spacecraft should be like the ones in airplanes. But controls based on the stick and rudder may not be best way to manually control a vehicle in space. A different method is based on submersible vehicles controlled with foot pedals. A new pilot can learn the sub's control scheme in minutes and drive it hands-free. We are building a pair of foot pedals for spacecraft control, and will test them in a spacecraft flight simulator.

RELEVANCE/ VALUE TO NASA

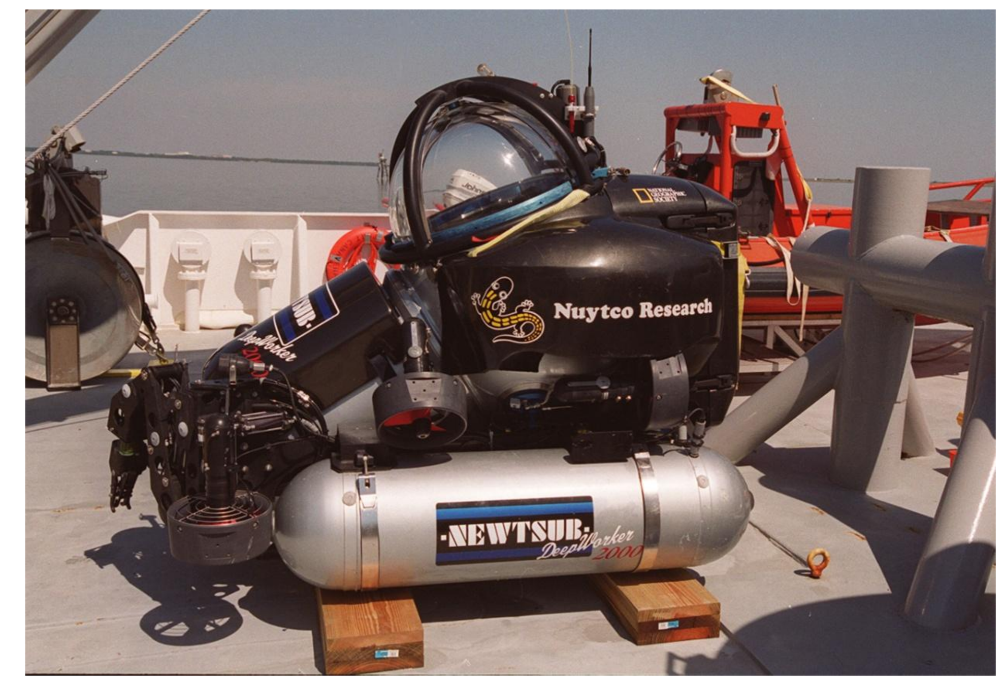
Engineers at JSC are now designing the cockpits of future spacecraft. A novel scheme for manual vehicle control may be of great value for their work.

OBJECTIVES & OUTCOMES

- Mechanical fabrication of the first prototype (four control axes) is now in work. Electronics fabrication is complete.
- The first prototype will be complete and available for simulator "test flights" by September 2012.

INFUSION POTENTIAL

- This project is directly applicable to the Flight Deck of the Future, the Multi-Mission Space Exploration Vehicle, and other JSC future vehicle projects. If successful here, it could find wider application in commercial spaceflight.



The DeepWorker 2000 submersible is a simple and successful vehicle that uses foot pedals for 4-axis motion control.

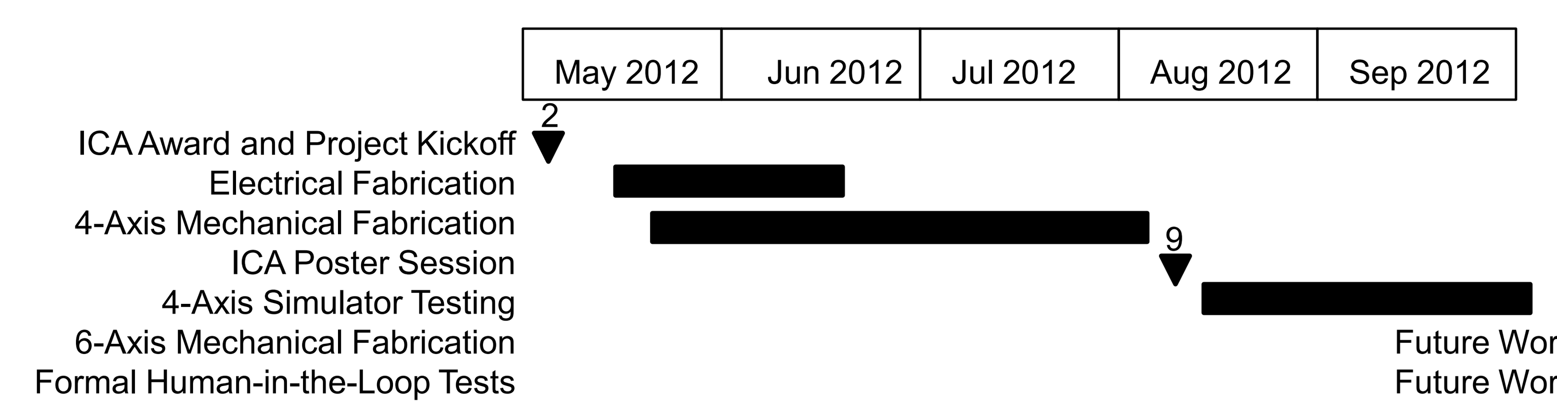
Pedals, articulation mechanisms, centering mechanisms, and microswitch wiring harnesses for this project as of July 9.

NASA TECHNOLOGY AREA ROADMAP

This project aligns with the following NASA Technology Area Roadmap areas:

- TA 06-12, Human Health and Performance.
- TA 04-9, Human-Systems Interfaces.

PROJECT DEVELOPMENT SCHEDULE



Project Start TRL (1-9): 6 (marine environment)
Current TRL (1-9): 6 (spacecraft simulator)

Novel Ultrasound Assessment of Dynamic Muscle

PI: Jessica Scott/USRA, jessica.m.scott@nasa.gov; 281.483.8398. Collaborators: Natalia Arzeno/Wyle; Timothy Caine/Wyle; David Martin/Wyle; Jacqueline Perticone/NSBRI; Kyle Hackney/Wyle; Lori Ploutz-Snyder/USRA.

PROJECT OVERVIEW

- Reports on skeletal muscle atrophy are typically based on study of cross-sectional area, a measurement that ignores more detailed changes in skeletal muscle form and structure during contraction. The use of novel and portable ultrasonographic techniques to evaluate dynamic skeletal muscle morphology may provide critical information regarding the underlying mechanisms of microgravity-induced strength and performance loss.

RELEVANCE/ VALUE TO NASA

- Information characterizing skeletal muscle morphology is of fundamental importance for sustaining human presence in space and extending the exploration of our Solar system.

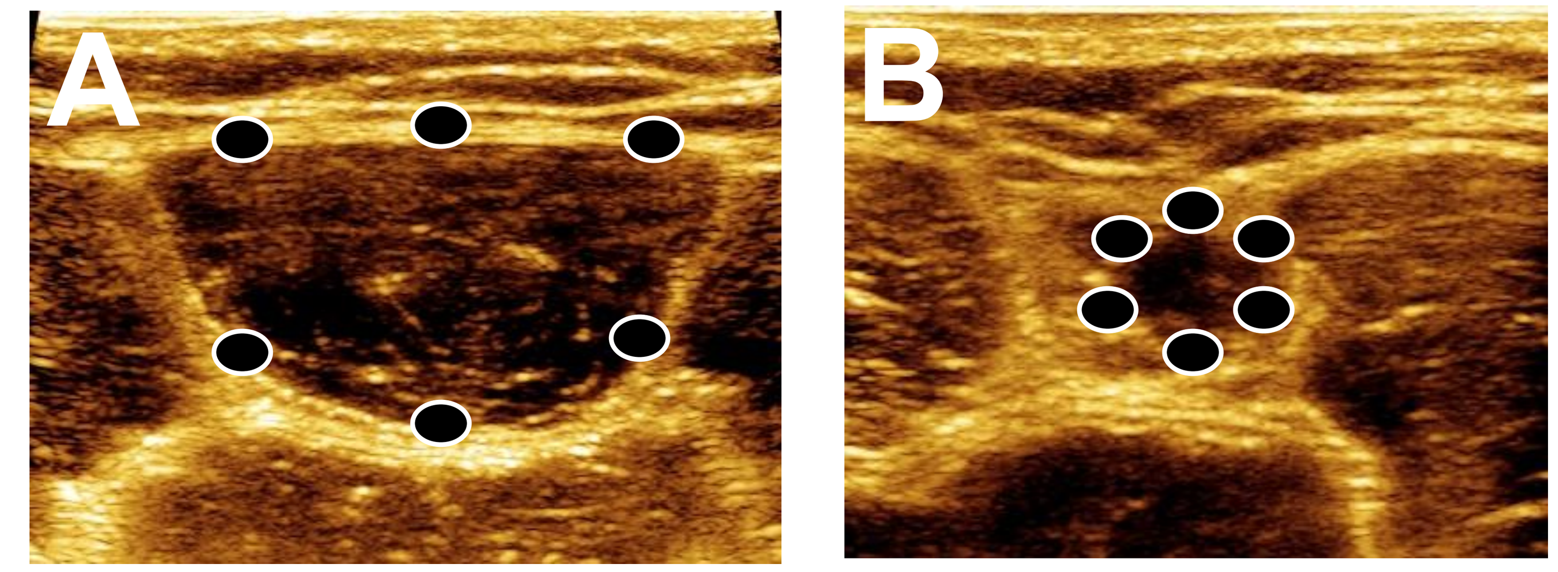
OBJECTIVES & OUTCOMES

- We have completed baseline ultrasound data acquisition, developed a novel MATLAB analysis program, and have acquired pilot ultrasound data.
- The final product of this study will be a novel assessment method that can improve characterization of skeletal muscle morphology. An additional product will include a manuscript detailing the innovative technique and the applicability of assessing skeletal muscle form and structure in a microgravity environment.

INFUSION POTENTIAL

- The new assessment technique will be used to further assess dynamic skeletal muscle structure using subjects participating in a microgravity analogue study. This study will specifically examine the impact of disuse on dynamic skeletal muscle morphology and function. Ultimately, it is anticipated that this technique will be used by long-duration astronauts as a tool to assess muscle structure and function in-flight so that augmented countermeasures can be implemented if declines are observed.
- This novel technique could also be used to enhance the understanding of skeletal muscle atrophy in bed-ridden patients and sarcopenia in older individuals.

Acquisition of dynamic skeletal muscle

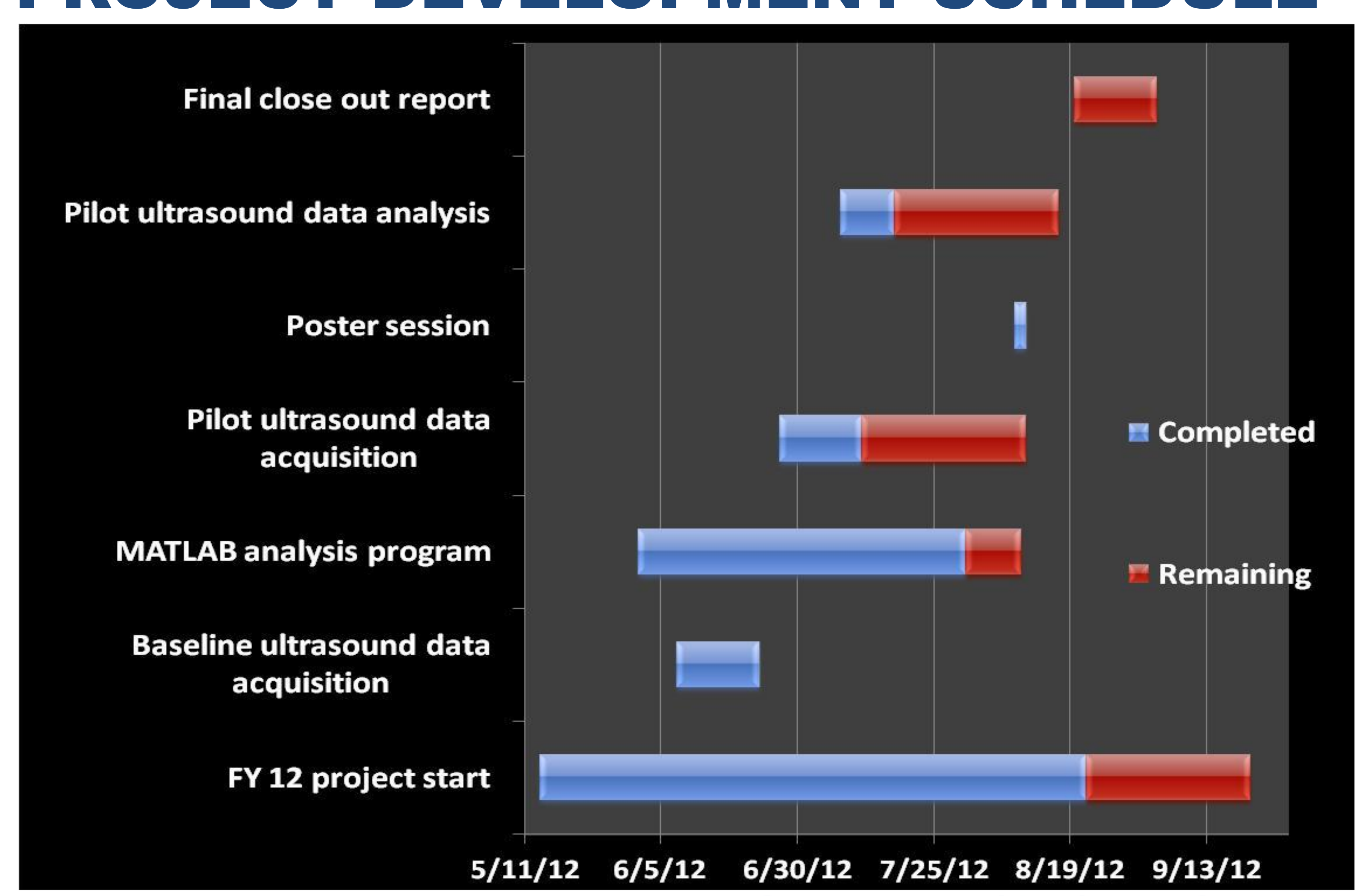


Tracking dynamic skeletal muscle (rectus femoris) in A) relaxed state; B) contracted state

NASA TECHNOLOGY AREA ROADMAP

•This project directly focuses on the TA 06 ‘high priority’ long duration health to provide a novel technology that will enhance a crew’s ability to effectively, reliably and safely complete long-duration mission tasks.

PROJECT DEVELOPMENT SCHEDULE



Project Start TRL (1-9): 2; Current TRL (1-9): 3

Crew Health And Recreation Gear Exercise Device (CHARGED)

Michael Li, ESCG, 281-461-5376, feng.li@escg.jacobs.com

Satish Reddy, ESCG, 281-461-5533, satish.reddy@escg.jacobs.com

Christine Gebara, ESCG, 281-461-5398

PROJECT OVERVIEW

- A magneto-Rheological (MR) fluid based exoskeleton leg demonstrator was developed to help long duration exploration mission crews obtain exercise with entertainment during flight and at their destination.

RELEVANCE/ VALUE TO NASA

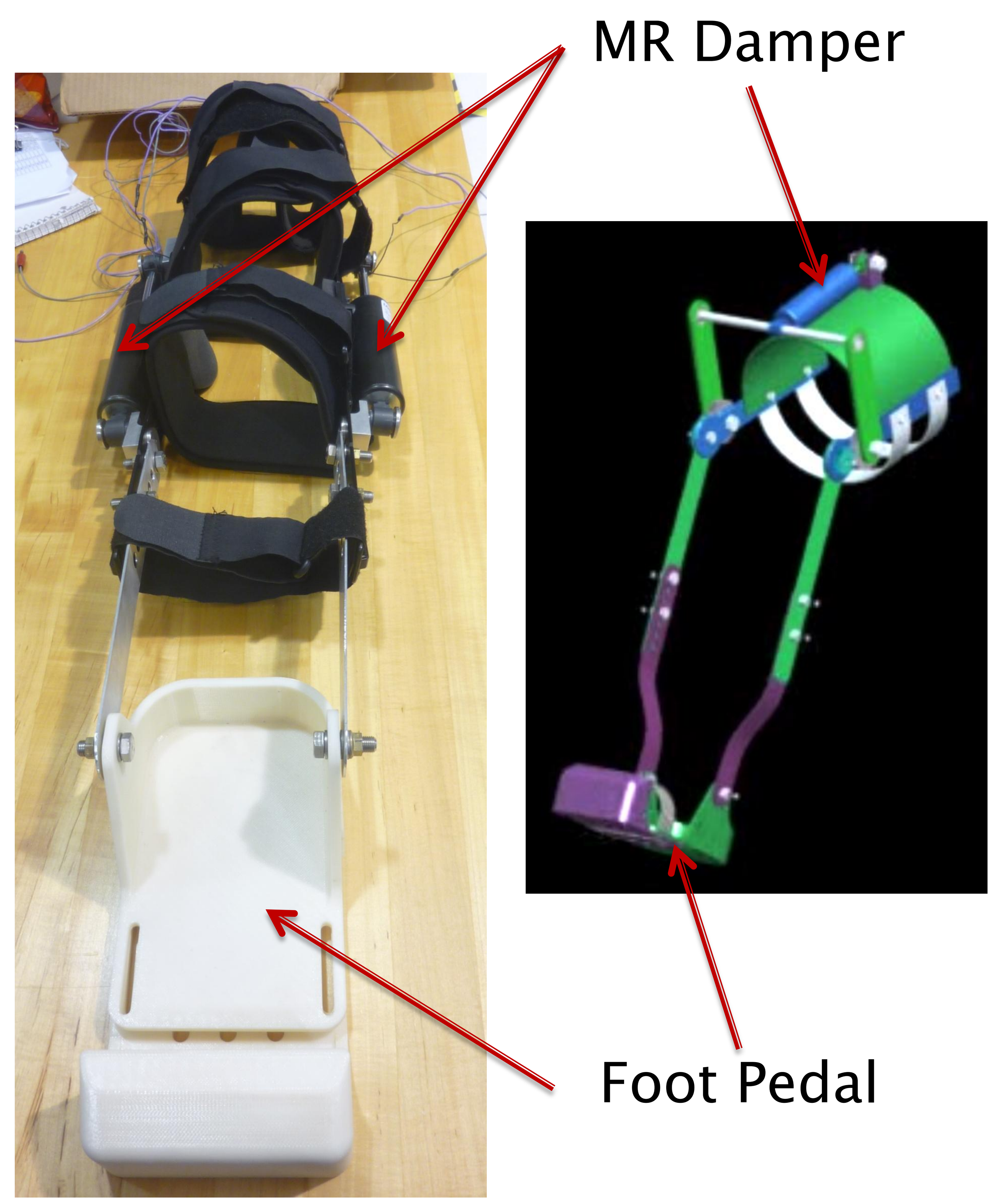
- This technology is to replace the bulky, high maintenance exercise devices (as used currently in the ISS) for long duration missions

OBJECTIVES & OUTCOMES

- Demonstrate that large compressive forces can be driven through the lower leg bones with the help of the foot pedal.
- A prototype of the leg demonstrator, math model, and test report.

INFUSION POTENTIAL

- The vision is to eventually develop a one-piece crew exercise gear to replace existing exercise devices, such as TVIS, CEVIS, ARED, and T2, and add a recreation / entertainment capability for long duration space missions. JSC/ER and SF have expressed interest in it
- The MR damper used in this hardware is a commercial off the shelf item extensively used in modern cars. MR technology has been demonstrated to work well on the ISS in reduced gravity



NASA TECHNOLOGY AREA ROADMAP

- TA-06 – Human Health, Life Support and Habitation Systems

PROJECT DEVELOPMENT SCHEDULE

WBS	Task	Product/deliveables	Milestones	Schedule (weeks) 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	**Spring 2012 ICA kick-off**	Contract WAD	5/31/2012	♦															
2	**Design complete**	CAD model or sketch	6/22/2012																
3	**Fabrication complete**	Prototype with foot pedal	7/13/2012																
4	**Testing complete**	Concept confirmation	7/20/2012																
5	**IR&D poster session**	I&RD poster and presentation	8/9/2012										♦						
6	**Refinement complete**	Refined/optimized prototype	8/31/2012													♦			
7	**Project closeout**	Final report and presentation	9/14/2012																♦

Project Start TRL (1-9): 3
Current TRL (1-9): 4

Compact Termination for Structural Soft-goods

PROJECT MANAGEMENT

Bob Wilkes, ESCG, 281-461-5216, robert.wilkesjr@escg.jacobs.com

PROJECT OVERVIEW

- Glass fiber offers unique advantages for structural applications, but is hampered by a sensitivity to bend radius. The goal of this project is to determine the geometric limits of a potted end termination, and to assess weight and volume savings over a traditional sewn pin & clevis termination..

RELEVANCE/ VALUE TO NASA

- Space environments are particularly harsh for the high-strength fibers we have come to rely on for soft structures. Kevlar, Nomex, Nylon, and other synthetic fibers are broken down by exposure to the combination of vacuum, atomic oxygen, and ultra-violet radiation. Glass fiber does not have this same susceptibility, but requires an end termination that does not bend its fibers.

OBJECTIVES & OUTCOMES

- A series of tests which vary the size of a potted end termination to determine the minimum size needed to maintain full strength of the webbing.

INFUSION POTENTIAL

- Damage-tolerant inflatable habitats

NASA TECHNOLOGY AREA ROADMAP

- TA-06, Habitation Systems
- Application is for Space Colonization, specifically for inflatable structures made from structural soft-goods

PROJECT DEVELOPMENT SCHEDULE

	Current Schedule	Week Ending date											
	Milestones	6/15/2012	6/22/2012	6/29/2012	7/6/2012	7/13/2012	7/20/2012	7/27/2012	8/3/2012	8/10/2012	8/17/2012	8/24/2012	8/31/2012
		1	2	3	4	5	6	7	8	9	10	11	12
1	Analytical model development												
2	Procure / fab materials												
3	Produce samples												
4	Tensile test												
5	Summarize findings & report												

Project Start TRL (1-9): 3
Current TRL (1-9): 3
Final TRL (1-9): 4

Inside-Out Manufacturing of Multifunctional Composites

PROJECT MANAGEMENT

Charles S. Hill, ES4.
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PROJECT OVERVIEW

- Demonstrate process to manufacture a complex shaped composite structure with imbedded wiring and fluid handling without the use of tooling.
- Utilize the core as the tool and build parts from the inside-out, placing utilities before composite structure.

RELEVANCE/ VALUE TO NASA

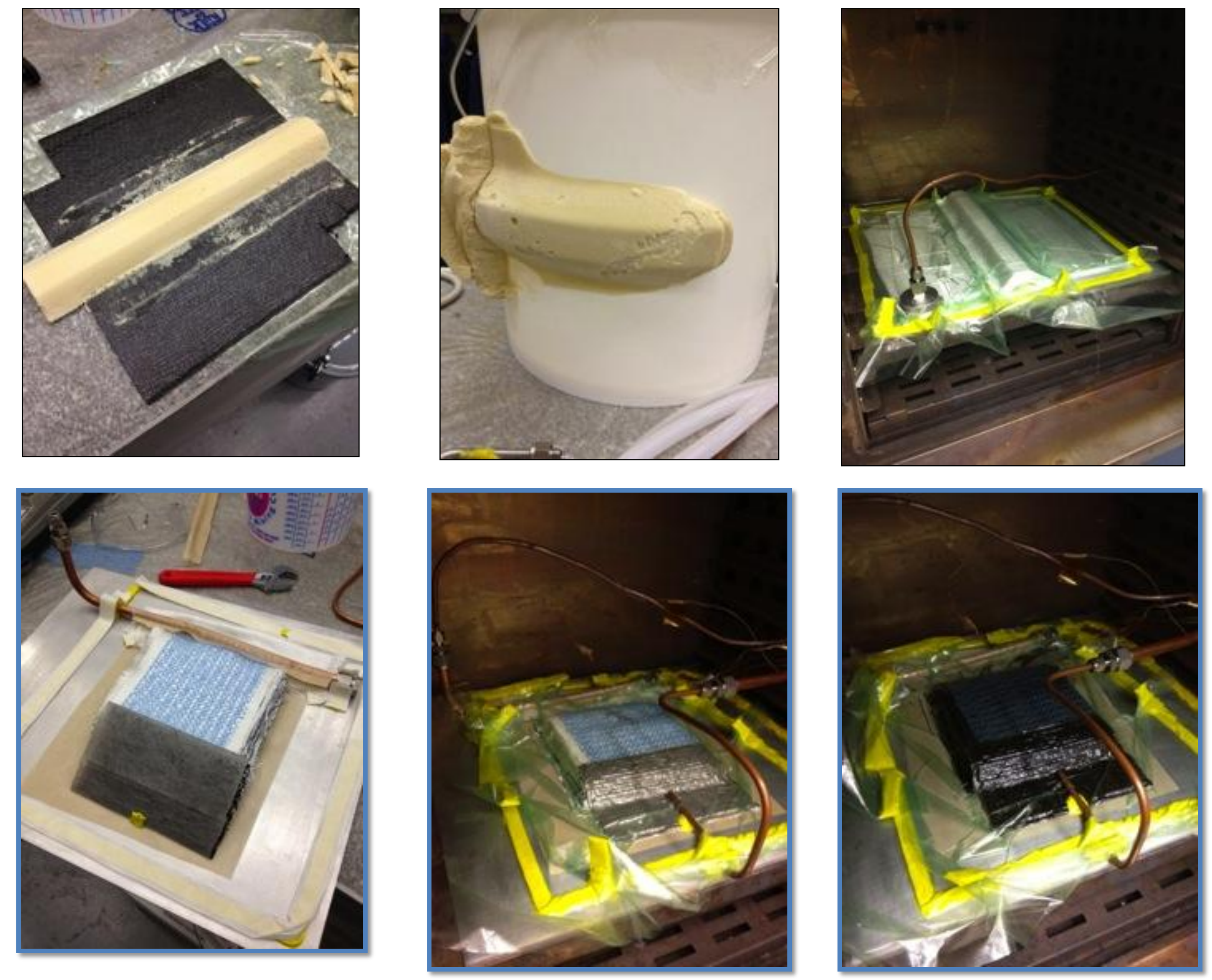
- Enables imbedding of service utilities in composite structures for protection and mass reduction.
- Reduces need for costly large tooling in low volume and prototype production.

OBJECTIVES & OUTCOMES

- Prove feasibility and illustrate utility of concept.
- Produced small complex part with wiring and fluid channels.

INFUSION POTENTIAL

- Evolved manufacturing process may be utilized in next generation spacecraft design as well as commercial transport, aircraft, and automobiles.



NASA TECHNOLOGY AREA ROADMAP

•: TA-12 .2.2 Structures:

- 12.2.2.1.1 Lightweight Concepts
- 12.2.2.5.2&6 Innovative, Multifunctional Concepts

PROJECT DEVELOPMENT SCHEDULE

•Collecting imbed-able electronic circuits, fluid channel and fittings.

•Identifying formable rigid core flat sheet and foam-in-place core materials.

•Assemble core with utilities, layup, bag and cure.

• Test internal circuits and fluid channels.

•Report Complete

•9/27/2012

Project Start TRL (1-9): 2
Current TRL (1-9): 3

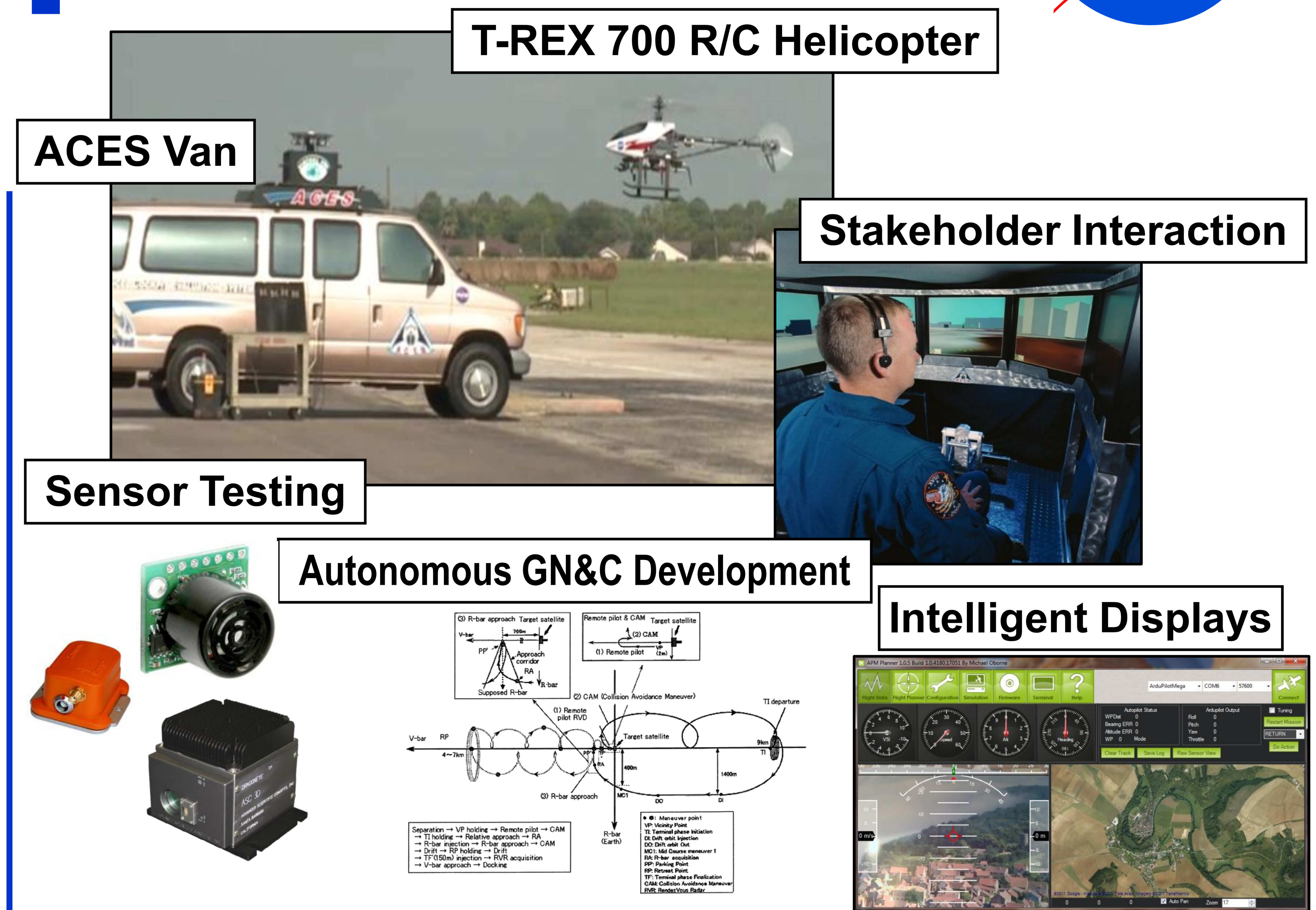
Future Autonomous and Automated Systems Testbed

FAAST

PROJECT MANAGEMENT

Angela Lenort/EG6

ph: 281-244-5491 e-mail: angela.n.lenort@nasa.gov



PROJECT OVERVIEW

FAAST is an R/C helicopter platform that is being developed by the Aeroscience and Flight Mechanics Division (EG) as a low-cost, low-risk, hands-on way for engineers to test autonomous and automated (A&A) system architectures, algorithms, and sensors. It is also envisioned as a platform for building trust in A&A systems among key stakeholders such as program/project management, crew members, and operators.

RELEVANCE/ VALUE TO NASA

Greater autonomy and automation in human spaceflight can:

- Reduce lifetime operations costs by decreasing dependence on ground systems and increasing configuration flexibility,
- Increase the amount of time devoted to science objectives by reducing crew workload, and
- Enable the Agency goal of conducting exploration missions beyond LEO where communication lag is a concern.

OBJECTIVES & OUTCOMES

Our intended product is a system capable of performing autonomous waypoint navigation, enabling future research into autonomous rendezvous and docking, takeoff, and landing.

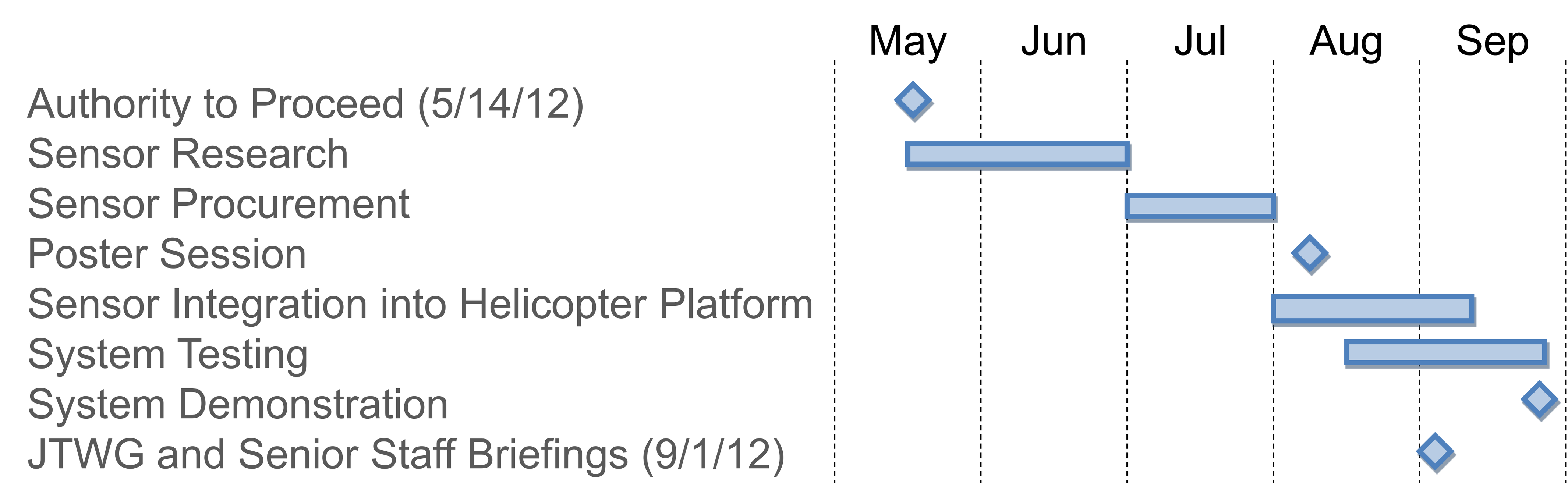
INFUSION POTENTIAL

- Perform JSC roof inspections for Center Operations.
- Potential Civil Air Patrol applications/partnership.

NASA TECHNOLOGY AREA ROADMAP

FAAST is aligned with the goals of TA04 (Robotics, Tele-Robotics, and Autonomous Systems) in the areas of Sensing & Perception, Mobility, Human-System Integration, Autonomy, and Autonomous Rendezvous and Docking.

PROJECT DEVELOPMENT SCHEDULE



Project Start TRL (1-9): 2

Current TRL (1-9): 3

Interface Anywhere

PROJECT MANAGEMENT

Max Haddock, NASA, Human Interface Branch/EV3, 281.483.7241, maxwell.d.haddock@nasa.gov

Shelby Thompson, Lockheed Martin, Habitability and Human Factors Branch/SF3, 281.244.8701, shelby.g.thompson@nasa.gov

David Overland, Human Interface Branch/EV3, 281.483.4304, david.overland-1@nasa.gov.

PROJECT OVERVIEW

- Current interfaces require controls in which the crewmember must stop during their task and move to a monitor and input device. Our goal is to demonstrate virtual control of an interface through a blend of voice recognition, gesture control, and projection technologies. Whereby, making it possible to control an interface from nearly any location.

RELEVANCE/ VALUE TO NASA

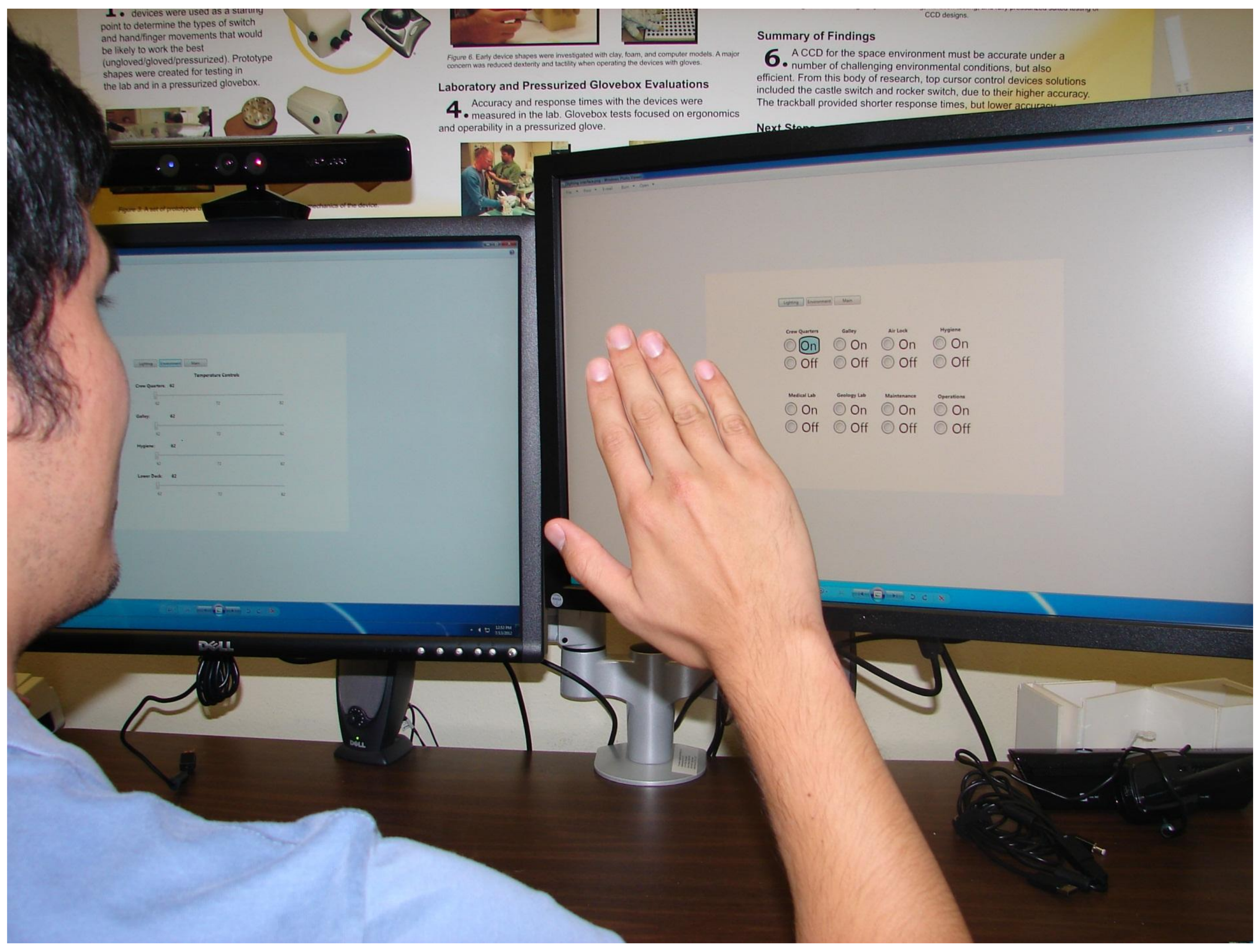
- Demonstrate the capability to decouple the control interface from a physical location in a spacecraft to any location.
- This all but eliminates crew productivity losses caused by work task interruptions to translate to physical control interfaces.

OBJECTIVES & OUTCOMES

- Conduct trade-studies between different technologies that would provide a mobile interface.
- Conduct human factors comparative evaluations.
- Produce a final report of the evaluations.

INFUSION POTENTIAL

- Project provides information that can be demonstrated in the Deep Space Habitat to outline further development.
- Commercialization using mobile interfaces and development of gesture technology.



Participant manipulating a prototype interface via the Kinect system.

NASA TECHNOLOGY AREA ROADMAP

- This new use of technology aligns with TA04.4.1 Multi-Modal Human-Systems Integration, 4.4.4 Intent Recognition & Reaction, Sensing & Perception, Integration.
- Human performance information will align with the Human Factors & Performance under TA06.

PROJECT DEVELOPMENT SCHEDULE

Milestones	May	June	July	Aug
Hardware Trade Study				
Device Control Virtualization				
Gesture Recognition and Control Development				
Mid-term TCSR, Poster Session				
Voice Control Development				
Testing and Integration				
Engineering Evaluation and Final Report				

Project Start TRL 2
Current TRL 3

Gesture Commanding of a Robot While Wearing EVA Gloves

PROJECT MANAGEMENT

Neta Ezer, Ph.D., Anikó Sándor, Ph.D. Human Factors and Habitability Branch, SF3

281-483-2226, neta.ezer@nasa.gov, 281-483-9726, Aniko.sandor-1@nasa.gov

PROJECT OVERVIEW

- Gesture commands allow a human operator to directly interact with a robot without the use of intermediary hand controllers.
- There are two main types of hand gesture interfaces:
  - Data glove-based devices are worn by the human and capture hand movements through embedded sensors.
  - Computer vision techniques interpret hand movements by using the video feed from cameras.
- The goal of the project is to assess the feasibility of both types of approaches when the person commanding a robot is wearing EVA gloves.

RELEVANCE/ VALUE TO NASA

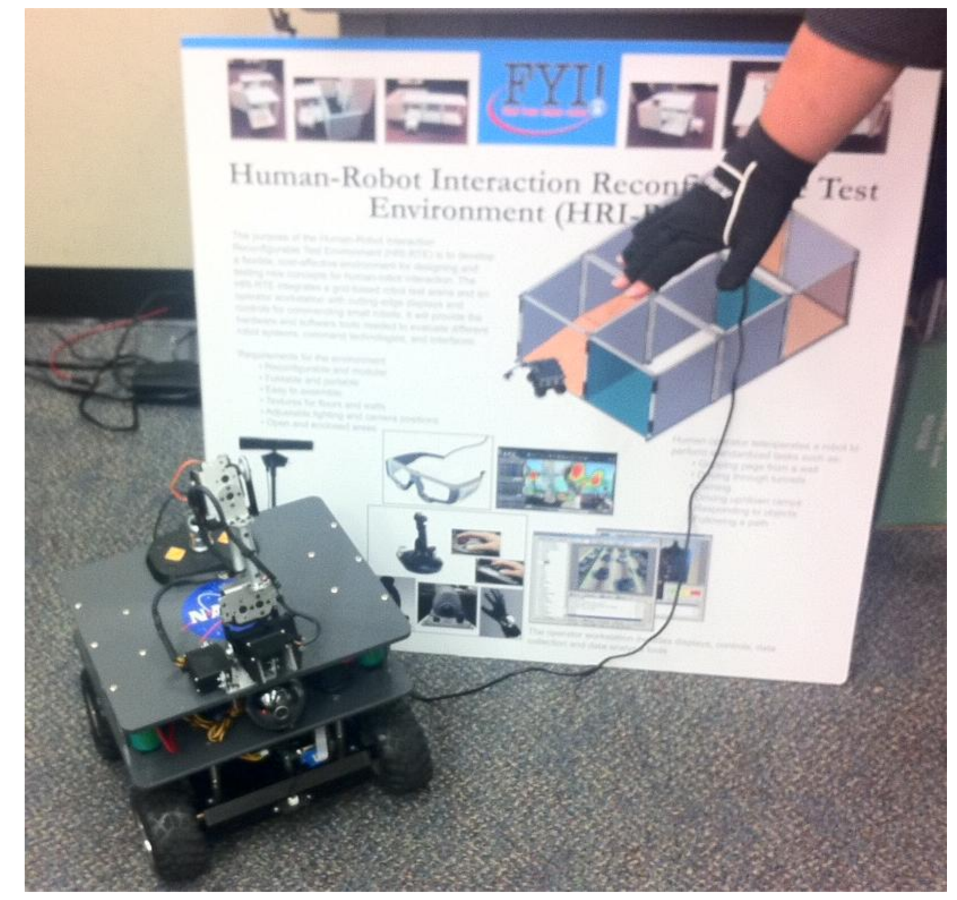
- Gesture commanding can be applied and evaluated with NASA robot systems. Application of this input modality can improve the way crewmembers interact with robots during EVA.

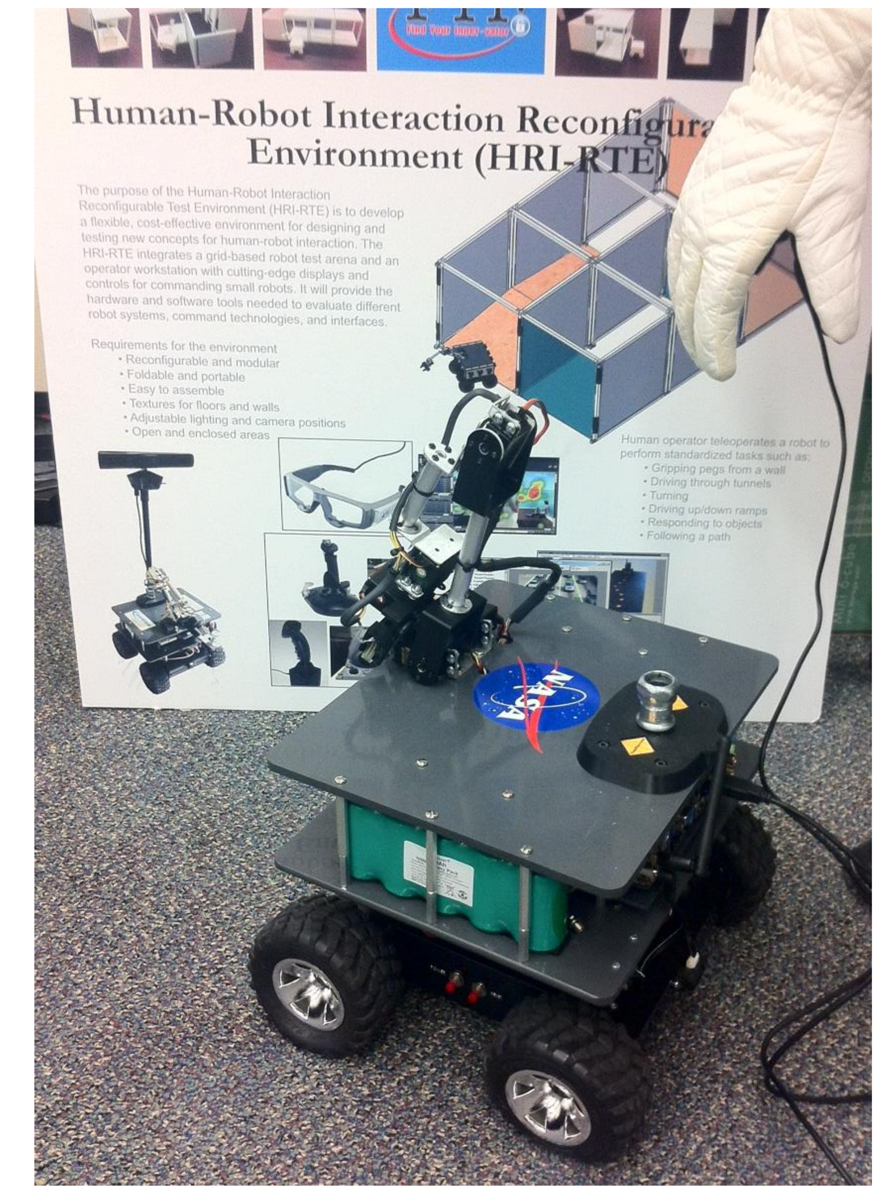
OBJECTIVES & OUTCOMES

- Program a small robot to accept inputs from a data glove inserted into an EVA glove and through computer vision software that can recognize gestures when the user wears an EVA glove. Evaluate approaches for increasing the recognition speed and accuracy of both gesture recognition methods.
- The outcome is a feasibility assessment of the data glove-based and computer vision techniques for commanding a robot through gestures. A demonstration of gesture commanding and outcomes of assessment will be provided.

INFUSION POTENTIAL

- If the results of the assessment show an advantage of one technique over another for commanding a robot with EVA gloves, in-depth studies can be proposed to refine and evaluate the gesture commanding method more thoroughly and develop a full gesture vocabulary.
- Work with the **VR lab** to share findings.
- Collaboration with **Flight Deck of the Future** (F.F)
- Technology developed will support the needs of the **Human Research Program**'s Directed Research Project on Human-Robot Interaction.
- The outcomes of the project can be used by other NASA systems that benefit from gesture recognition.





Robot with data glove and analog glove.

NASA TECHNOLOGY AREA ROADMAP

- TA04 Robotics, Telerobotic & Autonomous Systems/RTA Systems Engineering

PROJECT DEVELOPMENT SCHEDULE

	June	July	Aug	Sep
Project Start				
Develop gesture recognition software				
Program robot to accept gesture commands				
Evaluate gesture recognition methods				
Demonstration & Poster Session				

Project Start TRL (1-9): 3
Current TRL (1-9): 5

Stitched Camera Array for Clearance Monitoring

PROJECT MANAGEMENT

Innovator: Zach Drewry – DX2/MOD Robotic Systems, zachary.b.drewry@nasa.gov, 281.244.7726

Collaborators: Matt McGee – DA7/Space Flight Training Management Office

Jim Hansen – DA7/Space Flight Training Management Office

PROJECT OVERVIEW

- Quantify operational efficiencies gained by using video stitching software to provide robotics operators with enhanced 360° clearance monitoring in one view

RELEVANCE/ VALUE TO NASA

- Reduction in cost associated with mission plan-train-fly phases due to increased operational efficiency
- Advancing the state-of-the-art in clearance monitoring

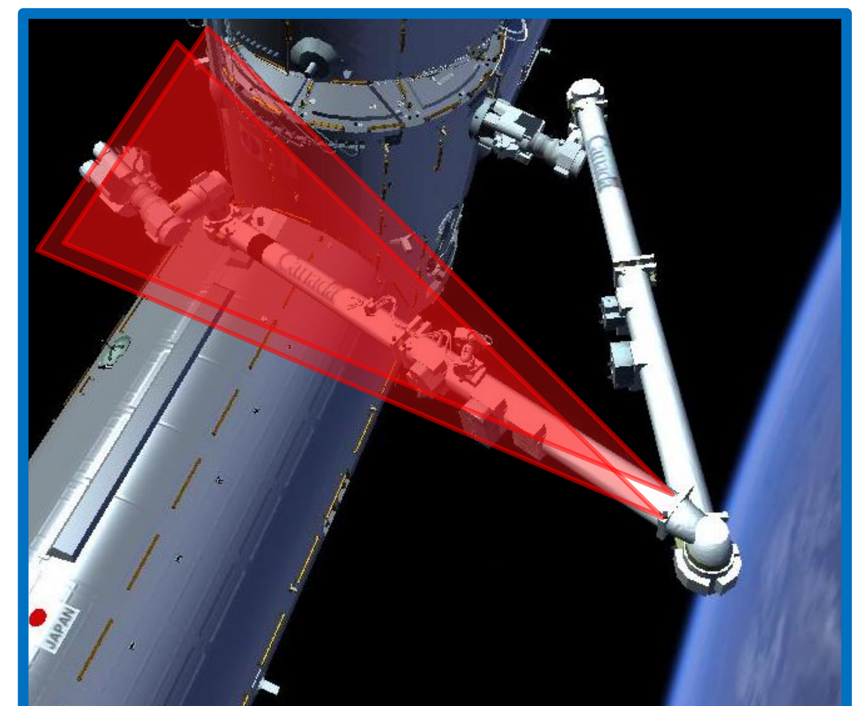
OBJECTIVES & OUTCOMES

- Obtain and ready test rig, develop test plan/script/ scoring, evaluate stitched camera array with test subjects
- Deliverable - white paper detailing the technology, test results, and suitability for use as clearance monitoring tool

INFUSION POTENTIAL

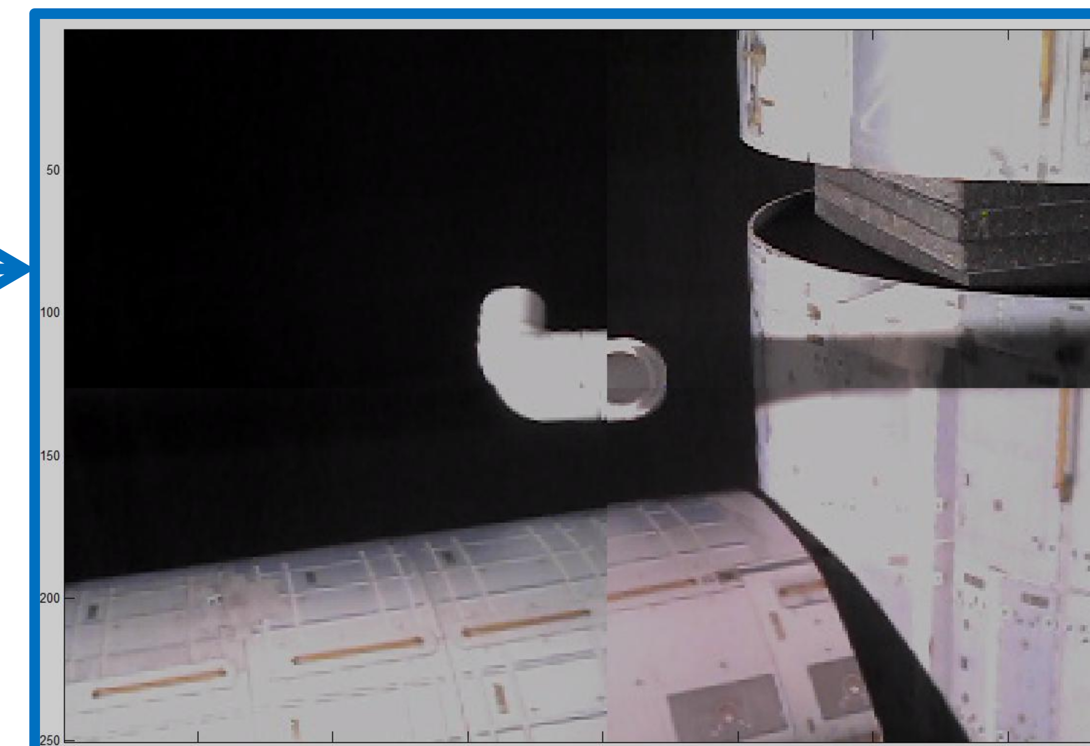
- Technology could be deployed on Space Station Remote Manipulator System (SSRMS) or underwater Robotic Arm at Neutral Buoyancy Laboratory (NBL)
- Other commercial applications include clearance monitoring for submersible remotely operated vehicles (ROVs), surgical instruments, or tele-robotics

Views from 4 individual cameras



Four Camera Array

Video Stitching Device



Composite View

NASA TECHNOLOGY AREA ROADMAP

- TA4.4– Robotics: Human-Systems Interfaces

PROJECT DEVELOPMENT SCHEDULE

Obtain and ready test rig	5/14/2012	5/28/2012	2.2w	
Develop test plan, script, scoring	6/4/2012	6/25/2012	3.2w	
Evaluate Camera with subjects	7/2/2012	7/23/2012	3.2w	
Write White Paper	7/30/2012	8/27/2012	4.2w	
JTWG dry run and final brief	8/27/2012	9/28/2012	5w	

Project Start TRL (1-9): 3

Current TRL (1-9): 5

Solar Powered Ceramic Oxygen Concentrator

PROJECT MANAGEMENT

PI: John Graf/EC3; Collaborator: Mike Ewert/EC2

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(281)483-9134; michael.k.ewert@nasa.gov

PROJECT OVERVIEW

- Developed countries have ready access to 3 different kinds of medical oxygen: bottled, cryogenic, pressure swing adsorption (PSA) generated.
- Developing countries don't have this and it costs lives.
    - Pneumonia is the #1 killer of children there.
- Our project seeks to change that by providing oxygen.

RELEVANCE/ VALUE TO NASA

- Space Station also needs pure oxygen and can make it 'out of thin air' with a ceramic oxygen concentrator.
- Solid state device that produces oxygen up to 300 psig without a mechanical compressor.

OBJECTIVES & OUTCOMES

- The objective is to convert the currently wall-powered (AC) ceramic oxygen concentrator to run on solar power.
- The product will be a proof-of-concept demonstration.

INFUSION POTENTIAL

- ISS has an immediate application post-shuttle.
- This is a very appropriate technology for medical oxygen in developing countries, which can save many lives.

NASA TECHNOLOGY AREA ROADMAP

•Oxygen production is part of technology area TA06, Human Health, Life Support and Habitation Systems: Air Revitalization.

PROJECT DEVELOPMENT SCHEDULE

•Solar power design & procurement	May-July
•Initial system assembly and test	August
•Oxygen storage sys. design & procurement	Aug/Sept
•ICA poster presentation	Aug 9
•Testing	Sept

Project Start TRL (1-9): 2

Current TRL (1-9): 3

Radiation Mitigation Theory

Innovator: Carl Swopes, WSTF-Jacobs, (575) 524-5123, carl.e.swopes@nasa.gov
Collaborators: Vernon Natewa, WSTF-Jacobs, (575) 524-5545, v.natewa@nasa.gov,
Michael Wnuk, University of Wisconsin, (414) 217-6665, mwnuk1@wi.rr.com,

PROJECT OVERVIEW

- This research is utilizing a recently discovered, math based color model. Using "Voltage as a function of time" [V(t)] equations with 3 new, unique, proportional, circular constants based on the golden ratio proportions.
- This peer reviewed "color model theory" argues that "color" is applicable to the entire electromagnetic (EM) spectrum, not just the visible light spectrum..
- An understanding of the mechanics of color via a proven, math based color model theory will facilitate the development of a radiation mitigation theory.

RELEVANCE/ VALUE TO NASA

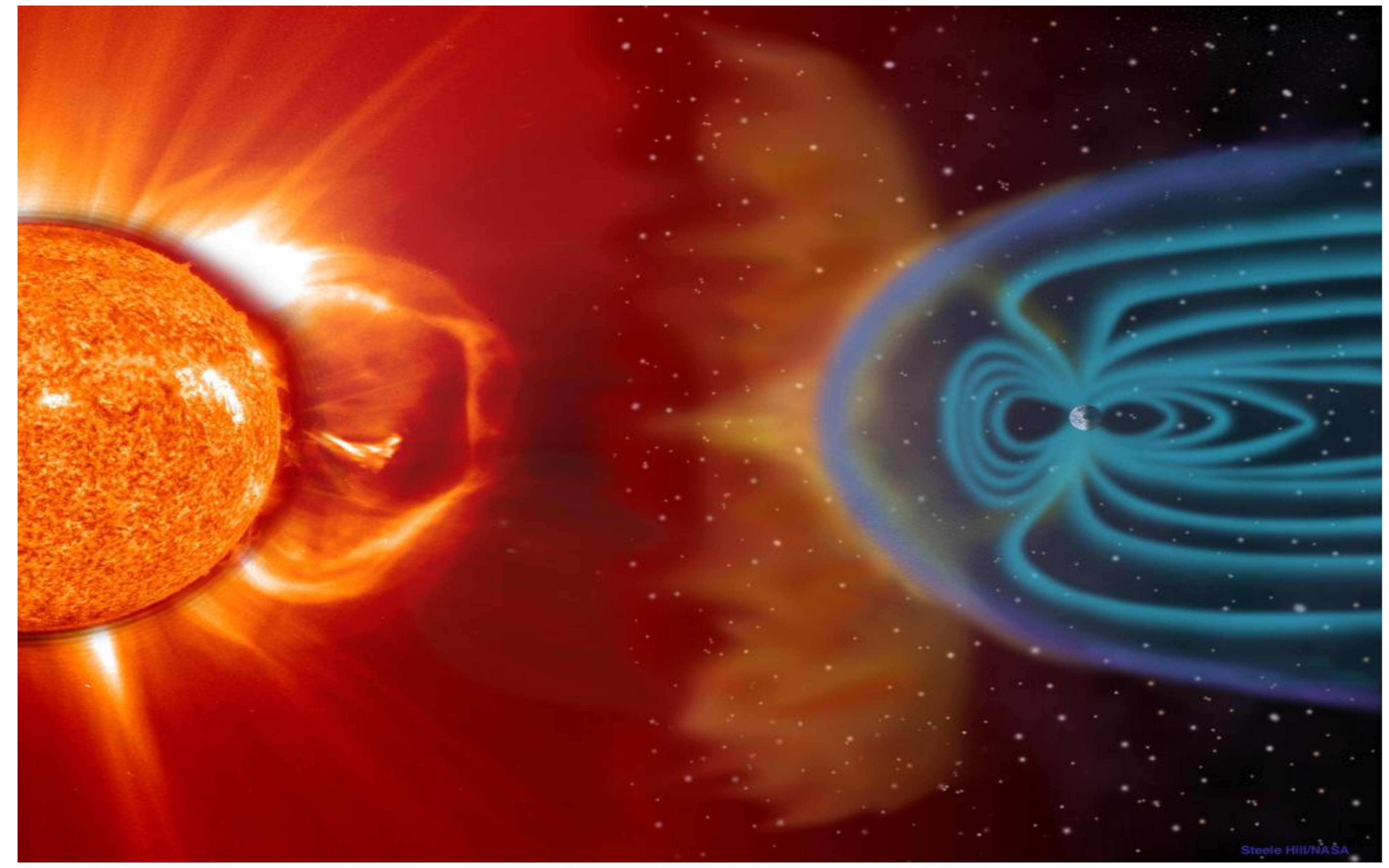
- A radiation mitigation theory will lead to the development of new technologies and/or materials in science and engineering. This will result in the mitigation of radiation sickness for astronauts and space colonists.

OBJECTIVES & OUTCOMES

- Research has identified a compatible math based color model represented by two exponential curves. .
- A final report on the findings will be provided.

INFUSION POTENTIAL

- Protect astronauts and space colonist from radiation sickness in NASA's space exploration programs.
- Protect power grids from radiation storms.
- Reduce line loss in power distribution systems.
- Reduction of heat in electrical components.
- Stealth technology to cancel or mitigate unwanted signals.

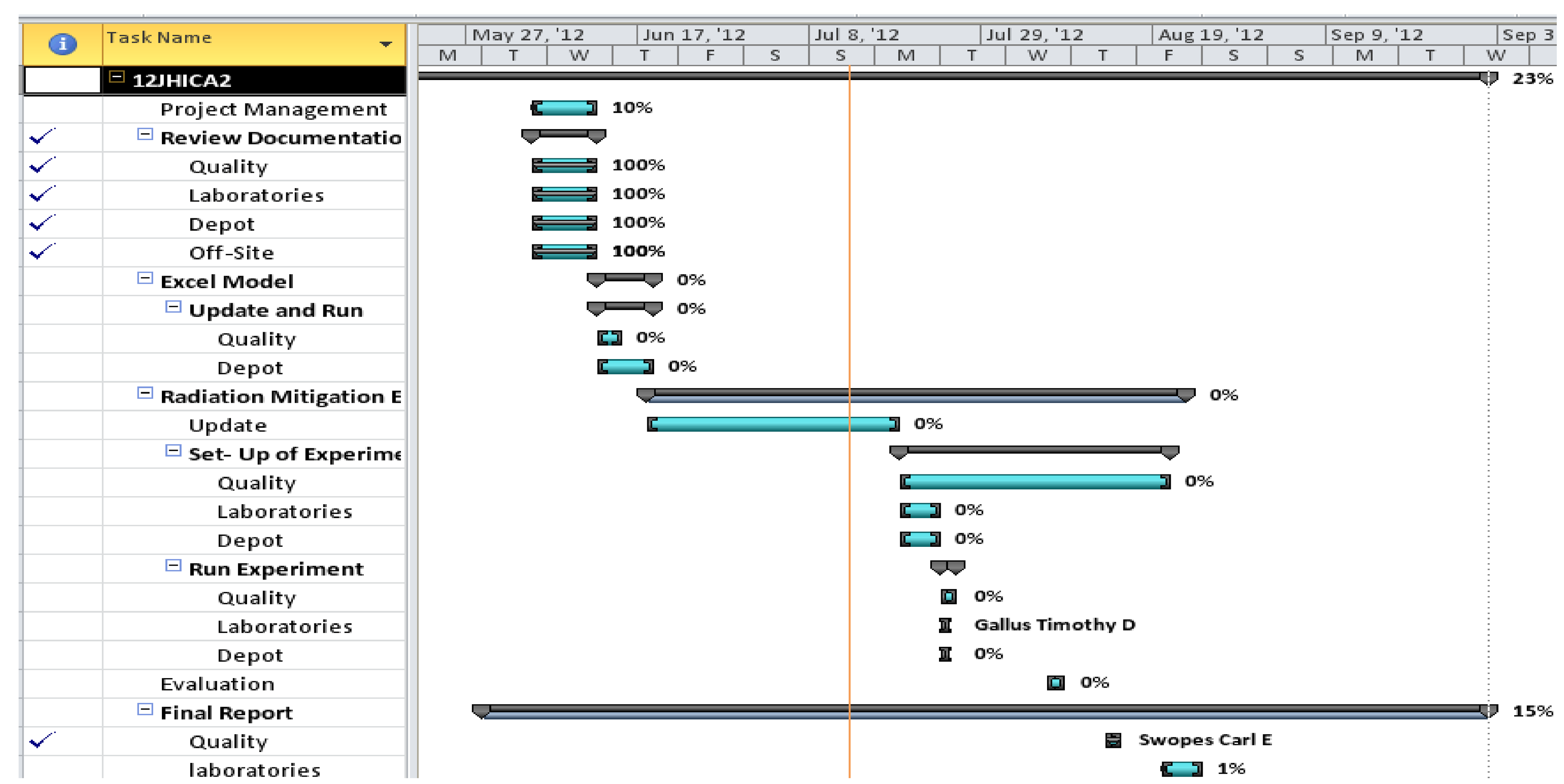


NASA/Solar Dynamic Observatory - sunearththemeSDO.tiff

NASA TECHNOLOGY AREA ROADMAP

- TA06 Human Health, Life Support and Habitation Systems WBS 2.5 Radiation; TA06 Radiation Mitigation/Biological Countermeasures.

PROJECT DEVELOPMENT SCHEDULE



Project Start TRL (1-9): 1
Current TRL (1-9): 1

Transparent and Instrumented Suit HUT for Mobility and Joint Strain Measurements

PROJECT MANAGEMENT

Sudhakar Rajulu, Human and Environmental Factors Div, NASA JSC

Matt Cowley, Lockheed Martin, Houston, TX

Joscelyn Mejias, Rice University, Houston, TX *

PROJECT OVERVIEW

Poor suit fit or functional design reduces performance and with frequent and strenuous suited training, can lead to injury. Data on human-suit interaction is difficult to obtain, but needed to improve future designs. This transparent hard upper torso (HUT) helps designers improve the quantity and quality of suited human data.

RELEVANCE/ VALUE TO NASA

Optimal suit designs reduce injury, increase comfort and improve performance.

OBJECTIVES & OUTCOMES

A transparent EVA-type HUT prototype was designed and built. The HUT is transparent and measurement friendly. This prototype allows for dynamic fit, mobility, and human-suit contact measurements to be made.

Following manufacture, pilot testing will quantify the data collection improvements.

INFUSION POTENTIAL

This prototype should greatly increase both the amount of data on suit-human interactions as well as the overall fidelity of the data. If deemed successful by stakeholders, this technique will be repeated in future suit design and development processes

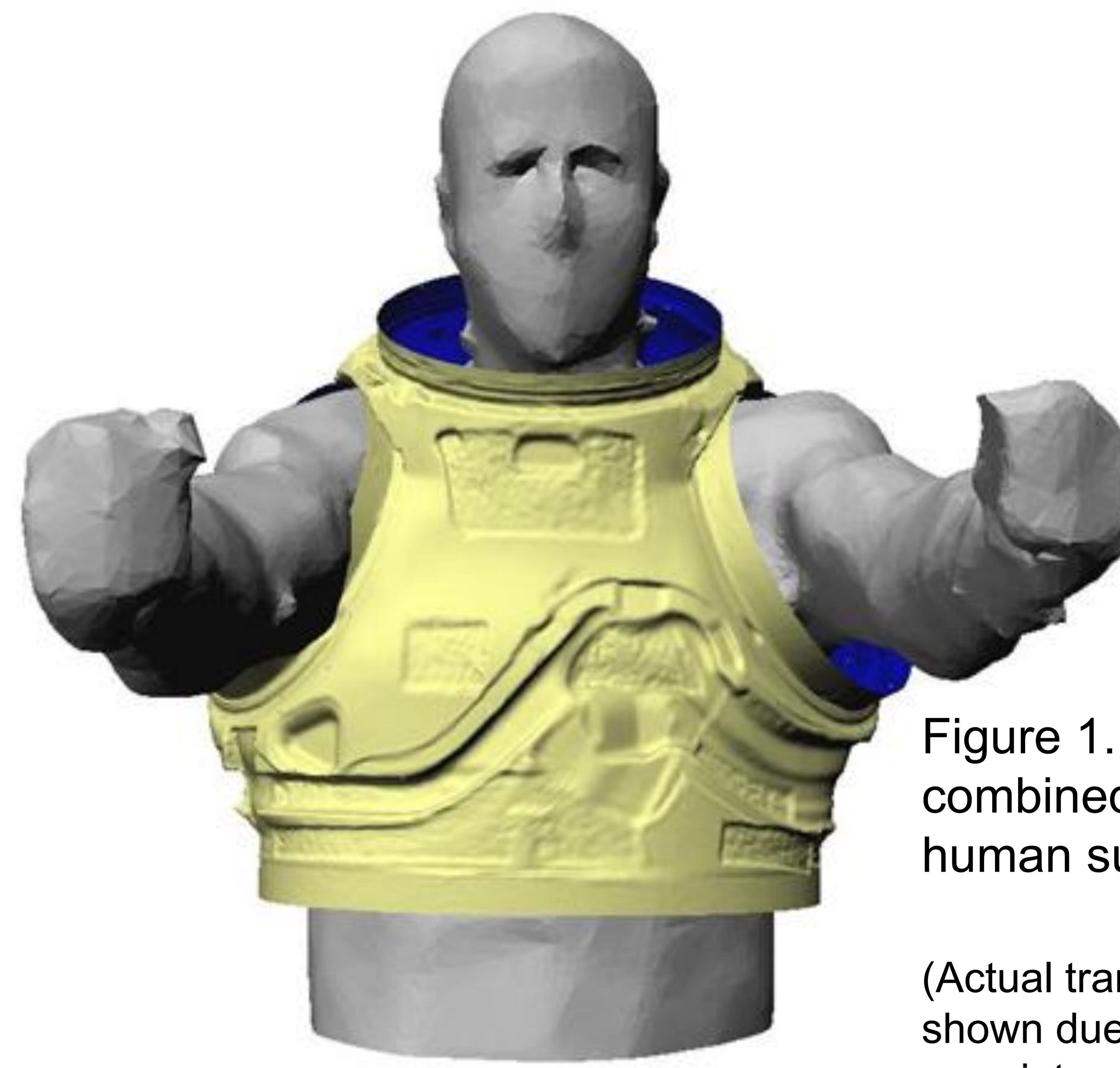


Figure 1. EMU HUT scan combined with a large human subject.

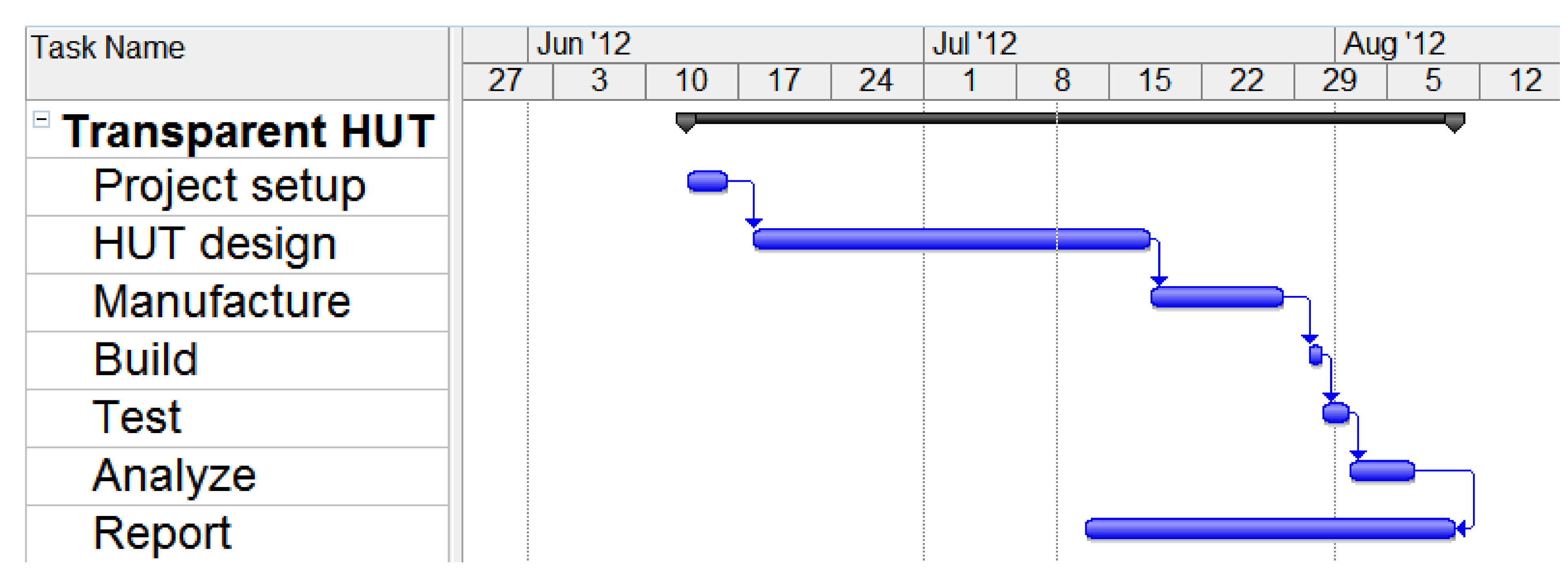
(Actual transparent HUT not shown due to NASA proprietary issues)

NASA TECHNOLOGY AREA ROADMAP

This project applies to the following roadmaps

- TA06: 2.2.1 Pressure Garment
- TA07: 7.3.1 EVA Mobility

PROJECT DEVELOPMENT SCHEDULE



* This investigation was sponsored in part by the National Space Biomedical Research Institute through NASA NCC 9-58

Project Start TRL: 2

Current TRL: 3

Textile Strain Gauge For Inflatable Structures

PROJECT MANAGEMENT

Doug Litteken, ES2, x30574, douglas.litteken@nasa.gov
Cory Simon, EV3, x31722, cory.l.simon@nasa.gov

PROJECT OVERVIEW

- Develop a gauge that can measure strain and thus load in the straps that make up the restraint layer of an inflatable structure. Current designs use strain gauges on metallic clevises at the ends of each strap, but only provide data at these distinct points.

RELEVANCE/ VALUE TO NASA

- A textile gauge will provide load data throughout the length of the strap and over the surface of the structure, which will allow for better analytical predictions and models and has potential use as an on orbit health monitoring system.

OBJECTIVES & OUTCOMES

- Initial design review was completed through technology research and collaboration of similar designs.
- Small scale testing was completed with a variety of potential solutions.
- Final gauge device was developed and tested with integration on a full scale strap in a tensile test machine to calibrate measured strain vs load.

INFUSION POTENTIAL

- Immediate implementation in upcoming Inflatable Structures testing.
- Can be applied anywhere that axial strain in a textile is important including the CPAS program and the automobile industry (seatbelts) .

FINAL DESIGNS:

DESIGN #1

Conductive thread sewn onto fabric using a cover stitch (Collaboration with Guido Gioberto, University of Minnesota) – As the fabric is stretched, the resistance in the stitch changes.

DESIGN #2

COTS Conductive polymer material to be adhered to fabric strap - As the fabric is stretched, the resistance in the polymer changes.

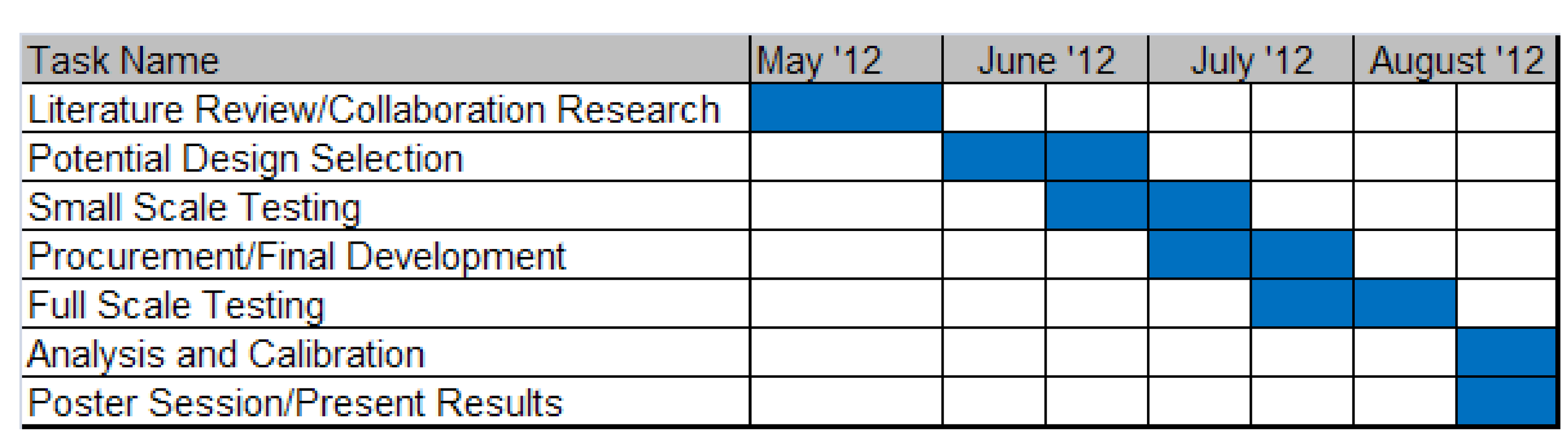
NASA TECHNOLOGY AREA ROADMAP

- Direct implementation with expandable structures, as mentioned as a Human Exploration Destination System in 7.4.2 Habitat Evolution.

PROJECT DEVELOPMENT SCHEDULE

<u>May 14 – August 31</u>

- May 25 – Literature review complete
- July 6 – Down-select design solutions
- August 6 – Execute full scale testing
- August 28 – Present final results



Project Start TRL (1-9): <u>1</u>
Current TRL (1-9): <u>3</u>

Ion Mobility Spectrometry for Water Monitoring

William T. Wallace/ SF2 / Wyle Science, Technology, and Engineering Group

Contact Info: william.wallace-1@nasa.gov / 281-483-2846

PROJECT OVERVIEW

- Ion mobility spectrometry (IMS) has previously been used on ISS to measure air quality and provides a potential opportunity to also measure water quality.
- Electrospray ionization (ESI) can be used to ionize water samples with no additional preparation for introduction into the ion mobility spectrometer.

RELEVANCE/ VALUE TO NASA

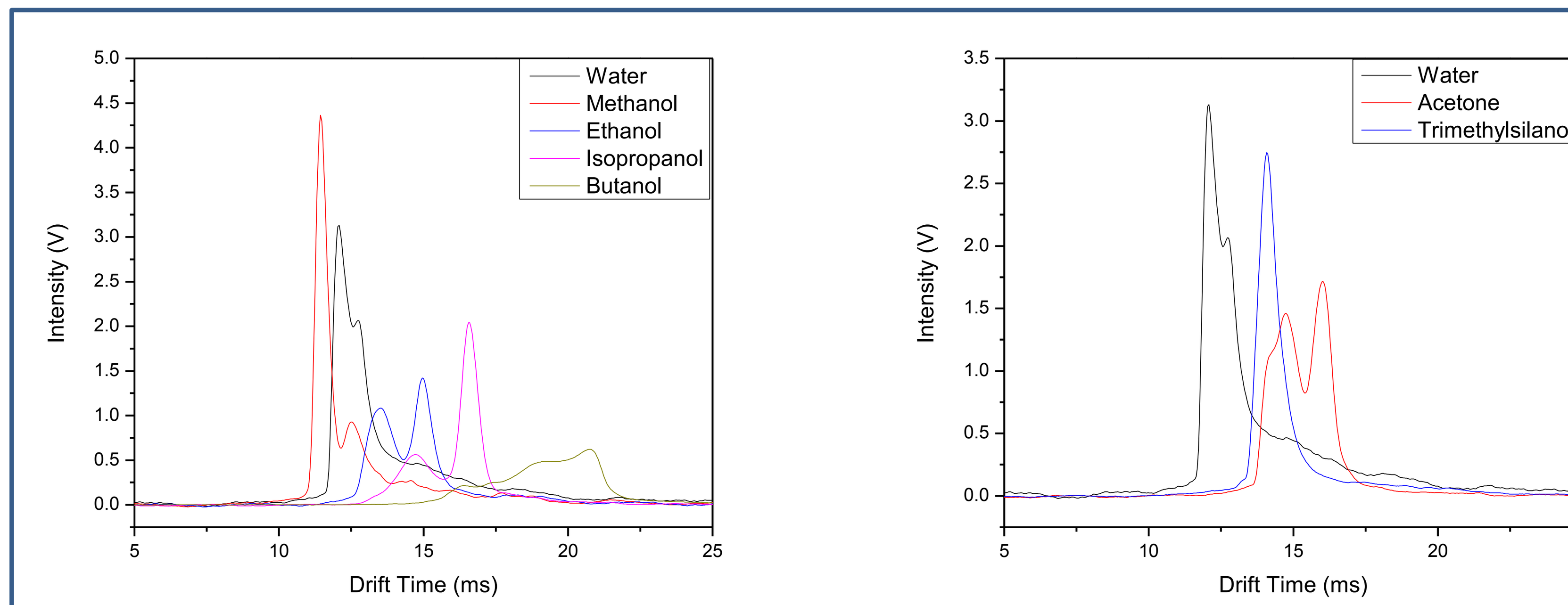
- The ability to analyze water samples (and possibility biological fluids) on orbit will limit/eliminate the need for sample return. Gaining insight into the concentration of specific trace contaminants will aid in mitigation approaches.

OBJECTIVES & OUTCOMES

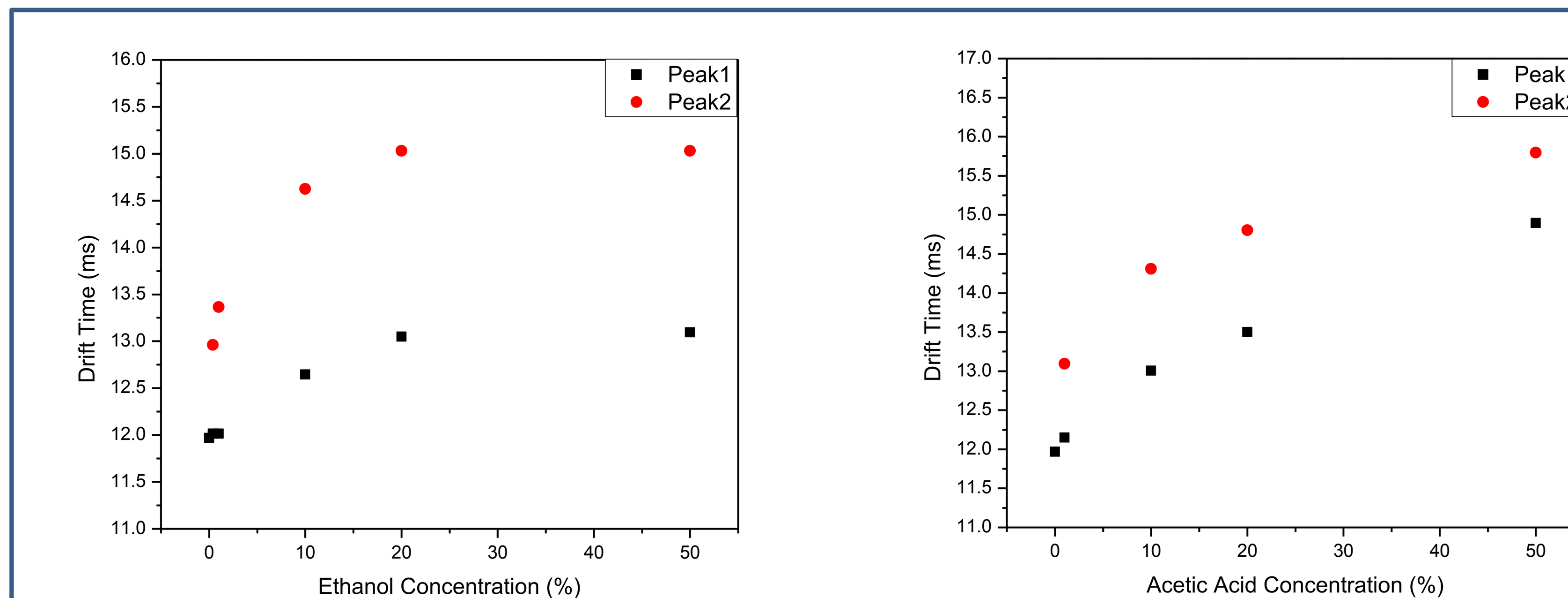
- The objective of this project is to construct an ion mobility spectrometer and combine it with ESI to test samples containing volatile organic compounds present in ISS water.
- The intended product of this work will be a report detailing the changes in drift time of different compounds entering the IMS as well as the effects of changing drift gas and matrix effects.

INFUSION POTENTIAL

- The ability to analyze water samples in real time makes IMS a potential analyzer for future exploration missions. Slight modifications to the ionization source would make it possible to analyze both air and water using a single unit.



Effect of compound size on drift time



Effect of concentration on compound drift time

NASA TECHNOLOGY AREA ROADMAP

- This project is relevant to TA-06 Human Health, Life Support, and Habitation Systems, aligning with 6.4 Environmental Monitoring, Safety, and Emergency Response.

PROJECT DEVELOPMENT SCHEDULE

Project: Ion Mobility Spectrometry for Water Monitoring							
Start Date: May 14, 2012 End Date: Aug. 31, 2012							
May 2012		June 2012		July 2012		August 2012	
Kick-off							
	Ordering and Construction of IMS						
			Testing of IMS with ESI source				
							Report

Project Start TRL (1-9): 2

Current TRL (1-9): 3

Variable Property Thermal Control Fluids

PROJECT MANAGEMENT

Thomas J Cognata: ESCG, 2814615415, thomas.cognata@escg.jacobs.com
and Moses Navarro: ESCG, 2814615414, moses.navarro@escg.jacobs.com

PROJECT OVERVIEW

- Spacecraft designed to meet current safety standards use a two-loop thermal control architecture. This project explores the merit of dynamic fluids as a technology to enable single loop architecture. A dynamic fluid is a solution or suspension where the composition is adjusted to tailor fluid properties throughout a mission to a spacecraft's environment.

RELEVANCE/ VALUE TO NASA

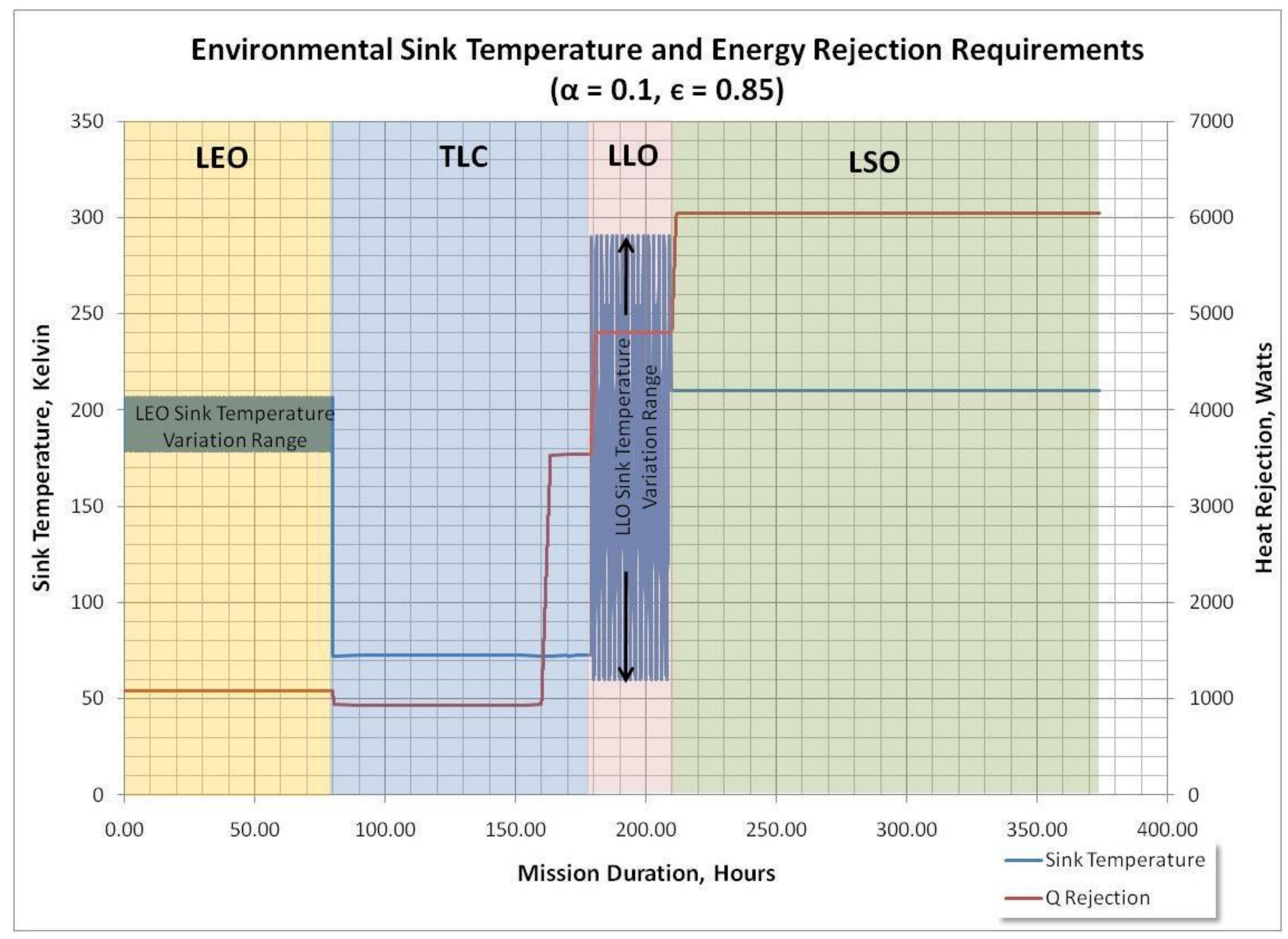
- This promises mass and volume savings by enabling a single loop thermal control architecture.

OBJECTIVES & OUTCOMES

- Evaluate merit by modeling adjustable PGW in portions of a lunar mission. Early results indicate a 17% increase in turn-down ratio using a dynamic range of 10 to 60% PG vs. 50% PG.
- Modeling results and a survey of dewatering technologies, given merit, will be presented.

INFUSION POTENTIAL

- The advanced thermal group within EC2 has been investigating single loop enabling technologies. The merit of this technology may be further investigated and developed for spacecraft applications.



A dynamic mission environment requires a high turndown ratio.

- Has potential as a thermal working fluid with wider operating range than static PGW and better heat transfer properties than synthetic fluids such as Galden and Syltherm.

NASA TECHNOLOGY AREA ROADMAP

- This is a technological advancement and is relevant to the areas of Thermal Management Systems and Human Health, Life Support, and Habitation systems.

PROJECT DEVELOPMENT SCHEDULE

- Collect properties and data: May to July
- Develop radiator model: June to Aug
- Evaluate dynamic PGW: July to Aug
- Investigate PGW dewatering: Aug

Project Start TRL (1-9): 2
Current TRL (1-9): 3

Nano-Antenna For Terahertz (THz or T-Ray) Medical Imaging

PROJECT MANAGEMENT

Shian Hwu PhD, JSC/EV/ESCG/Barrios, 281-244-5731, Shian.u.hwu@nasa.gov

PROJECT OVERVIEW

- X-ray imaging could damage human tissues and DNA.
- T-ray imaging does not damage human tissues and DNA due to the non-ionizing radiation nature.
- Investigate/optimize nano-antenna designs using the state-of-the-art computer modeling tools.

RELEVANCE/ VALUE TO NASA

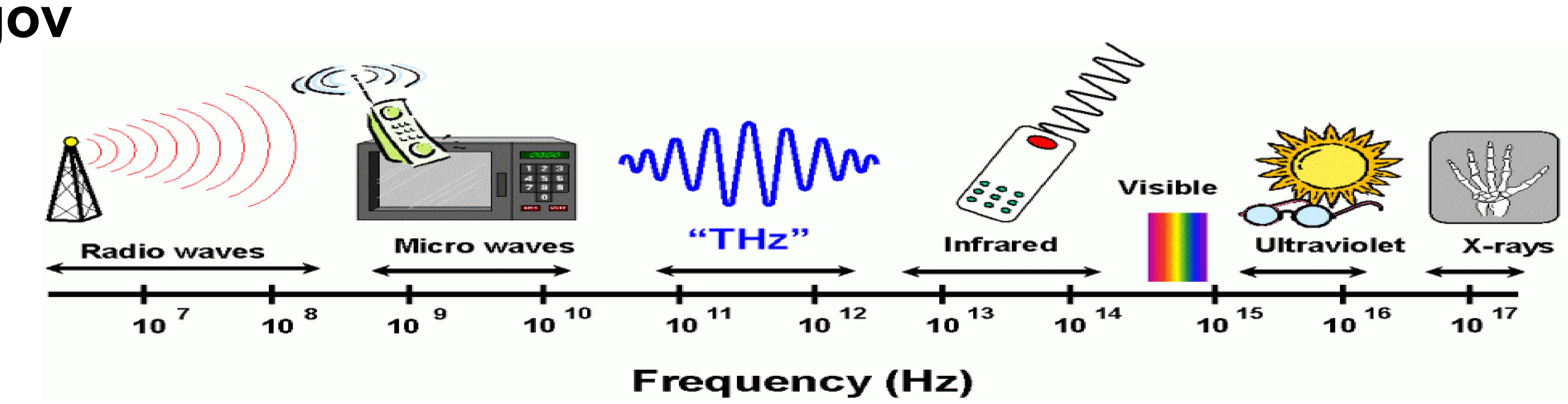
- THz technology has 30 years of applications in space radio astronomy
- T-ray imaging could inspect spacecraft damaging component non-destructively.

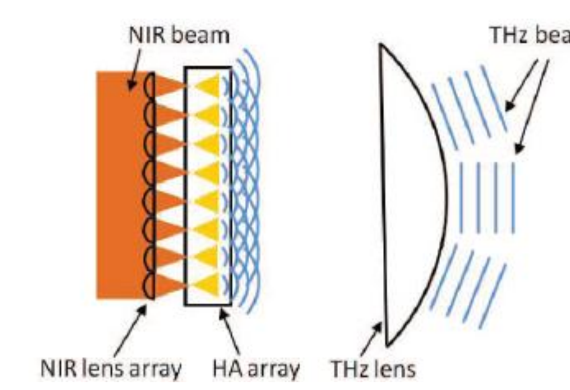
OBJECTIVES & OUTCOMES

- Optimize antenna design to increase radiation efficiency and maximize the THz emitter output power.

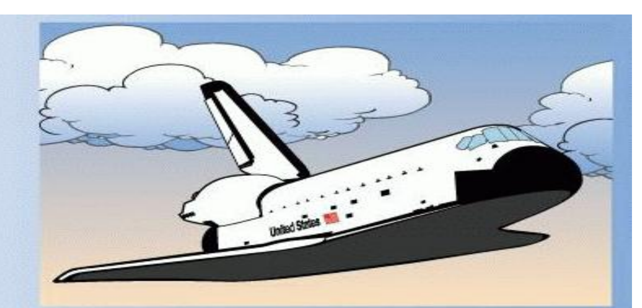
INFUSION POTENTIAL

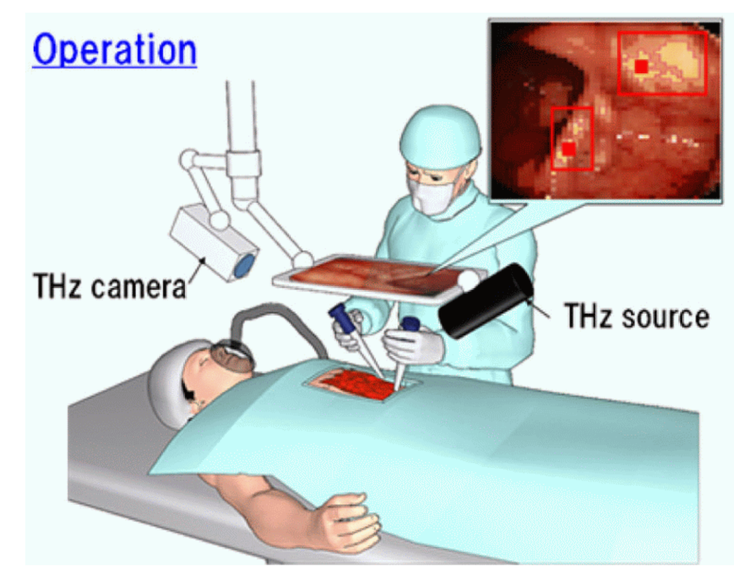
- For astronaut health management and spacecraft structural monitoring
- T-ray imaging facilitate the search for explosives for Airport Security applications.
- Effective detection of epithelial cancer
- Accurate 3D imaging in dentistry applications

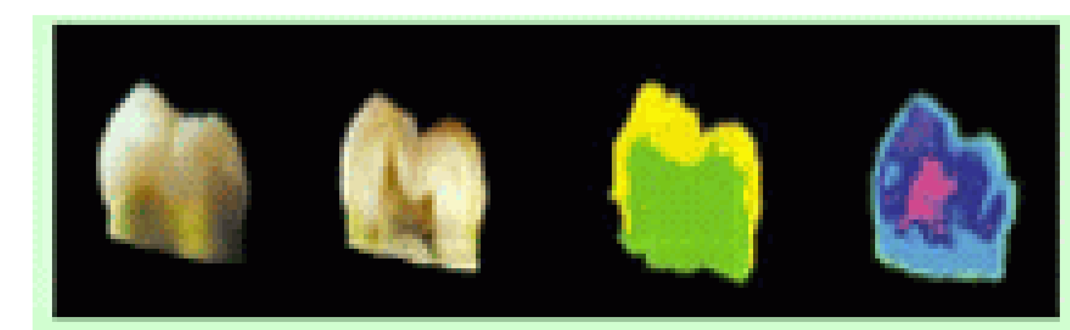





help airline pilots navigate through fog


detect dangerous flaws in space shuttle components

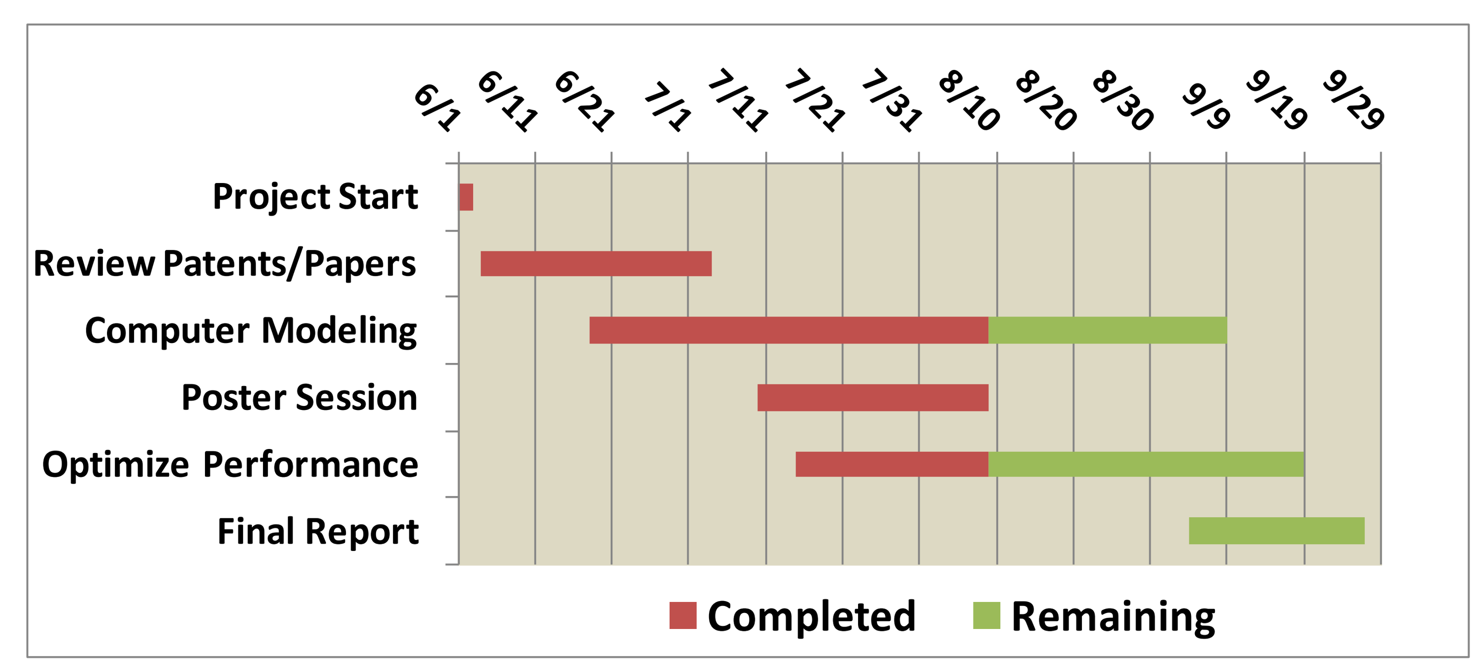




NASA TECHNOLOGY AREA ROADMAP

- TA10-17 Nanoelectronics, sensors and actuators are important research area for NASA's mission
- TA10-18 High sensitivity and detection capability and lower power than conventional sensors.

•PROJECT DEVELOPMENT SCHEDULE



Project Start TRL (1-9): #2
Current TRL (1-9): #3

Electrochemical Approach to In-Situ, Real-time Detection and Identification of Microorganisms for Manned Spaceflight

DANIEL GAZDA, DOUGLAS BOTKIN / SF2

SHANA KELLEY / UNIVERSITY OF TORONTO

CONTACT INFO: DANIEL.B.GAZDA@NASA.GOV , 281-483-6892

PROJECT OVERVIEW

- Currently, assessing the potential crew health risk associated with a microbial contamination event requires return of representative environmental samples.
- In this project, we are evaluating a novel detection platform that combines an electrical cell lysis chamber with an electrochemical reporter system that utilizes nanostructured microelectrodes (NMEs) for in-flight detection and identification of microorganisms.

RELEVANCE/ VALUE TO NASA

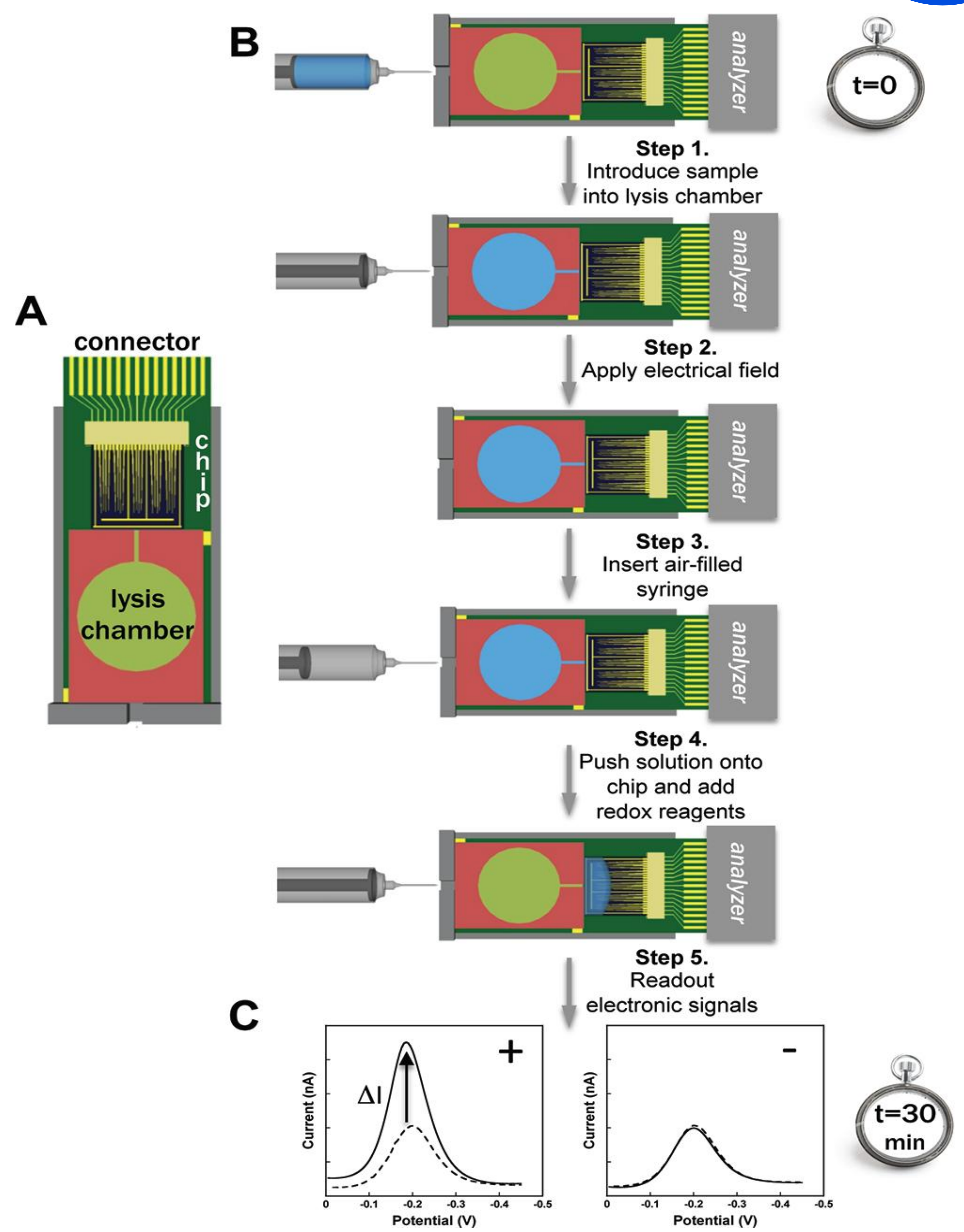
- By providing enhanced in-flight monitoring capabilities we can reduce reliance on archival samples and improve our response to in-flight contamination events.

OBJECTIVES & OUTCOMES

- The objective of this project is to develop and test devices capable of detecting and quantifying target organisms that were recovered from water samples collected on the ISS.
- A secondary objective is to evaluate the potential for the platform to differentiate closely related organisms as well as distinguish pathogenic vs. non-pathogenic organisms.

INFUSION POTENTIAL

- If this project is successful, follow-on funding would be required to develop a flight ready system based on this technology. However, the portability of the devices and capability provided addresses existing monitoring needs for both the spacecraft and terrestrial environments.



Lam, B., Fang, Z., Sargent, E. H., and Kelley, S. *Anal. Chem.* **2012**, 84, 21-25.

NASA TECHNOLOGY AREA ROADMAP

- This project is relevant to TA-06 Human Health, Life Support, and Habitation Subsystems, aligning with 2.4 Environmental Monitoring, Safety, and Emergency Response.

Project Start TRL (1-9): 1

Current TRL (1-9): 1

Integration of Voice and Gesture

PROJECT MANAGEMENT

David Overland/EV3
281-483-4304 david.overland-1@nasa.gov

PROJECT OVERVIEW

- Gesture and positional information provides context to speech. Recent consumer technology has lowered the entry level costs for both speech and gesture recognition.

RELEVANCE/ VALUE TO NASA

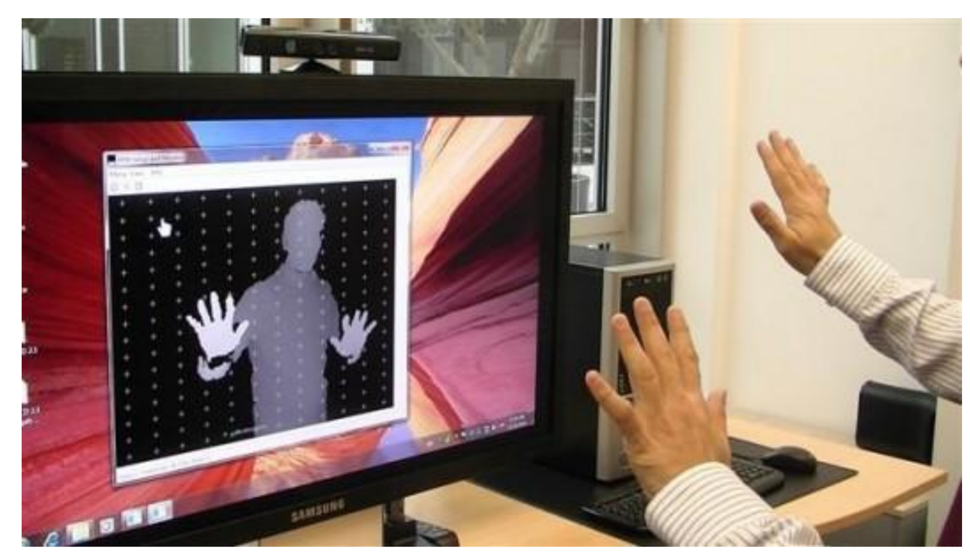
- Hands-free computer interaction allows astronauts more time to perform mission tasks.

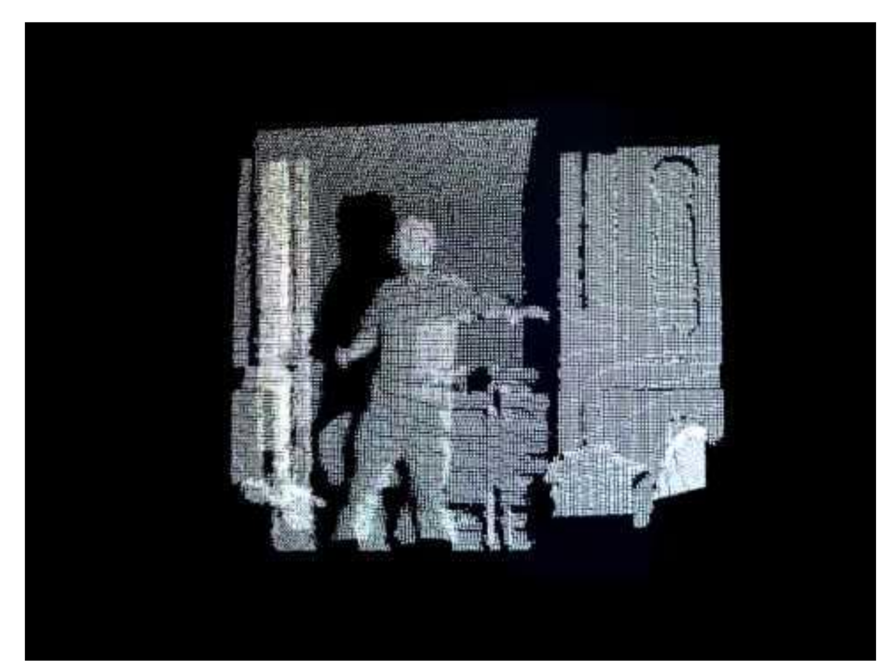
OBJECTIVES & OUTCOMES

- Survey of the technical field was accomplished. Basic software and hardware, including microphones, cameras and 3D depth sensors was procured.
- Basic equipment functionality has been demonstrated. Groundwork has been laid for continued efforts.

INFUSION POTENTIAL

- Working prototypes will be integrated into the Flight Deck of the Future (F.F). Design principles will be used to develop further prototypes addressing specific simulated mission objectives.
- Speech recognition technologies are being hosted in immersive environments (cars, living rooms). Gesture recognition exists in gaming consoles. Frameworks are still needed for integration.





NASA TECHNOLOGY AREA ROADMAP

- This project directly addresses **TA4.4.4 Intent Recognition and Reaction**. Determining "implicit operator intent" to provide speech context is the goal of this project.

PROJECT DEVELOPMENT SCHEDULE

Project Name	Days	Start	End	14-May	28-May	11-Jun	25-Jun	9-Jul	23-Jul	6-Aug	20-Aug	3-Sep	17-Sep
Integration of Speech & Gesture	136	14-May	27-Sep										
Spring ICA	136	14-May	27-Sep										
Project ATP	1	14-May	15-May										
Procure Hardware and Software	81	6-Jun	26-Aug										
Research existing prototypes	81	15-May	4-Aug										
Select prototype for rehosting	7	28-Jul	4-Aug										
Develop prototype and evaluate	56	28-Jul	22-Sep										
Poster Session	1	9-Aug	10-Aug										
Document white paper	21	6-Sep	27-Sep										

Project Start TRL (1-9): 2
Current TRL (1-9): 3

Hybrid Windows and Mosaic Video: Reducing Complexity of Space Habitable Modules

PRINCIPLE INVESTIGATORS

Helen Neighbors, NASA, (281) 483-0811, helen.neighbors@nasa.gov, EV3;
George Studor, NASA, (281) 415-3986, george.f.studor@nasa.gov, ES2.

PROJECT OVERVIEW

- Explore options for providing direct viewing and image sensing through arrangements of multiple, small portals that accommodate various cameras, sensors, and human eye.

RELEVANCE/ VALUE TO NASA

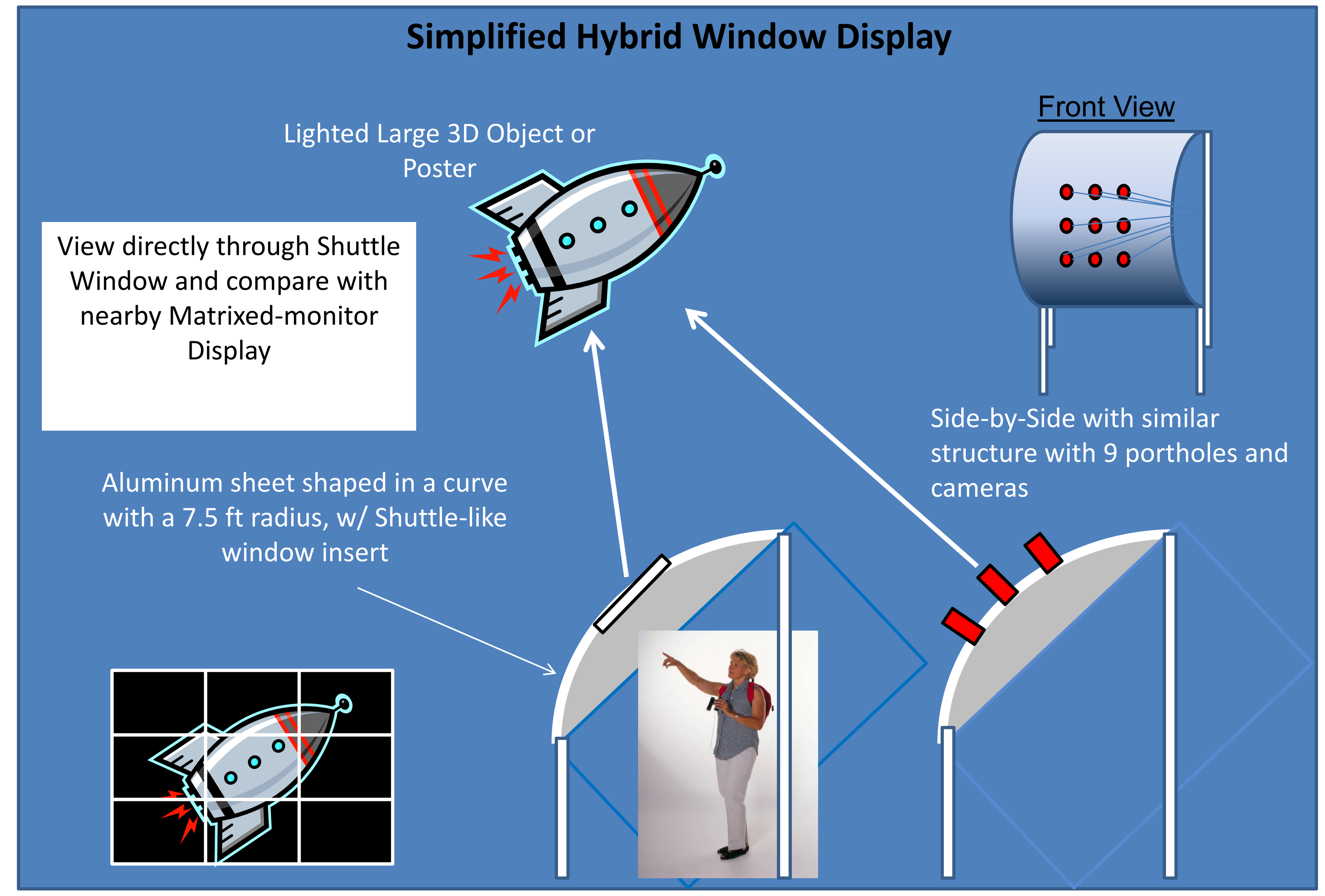
- Enhances design and adds more locations for, direct viewing; easier maintenance; represents less of an impact to a vehicle's structural integrity than traditional windows, and applies to aluminum, composite and inflatable structures.

OBJECTIVES & OUTCOMES

- Architectural studies and design;
- Demonstration and evaluation prototype to be built;
- Human Factors evaluation to be conducted;
- Test report to be generated.

INFUSION POTENTIAL

- Potential for infusion into JSC, MSFC Deep Space Habitat evaluation facility.
- Potential for infusion into undersea applications e.g. NEEMO.



NASA TECHNOLOGY AREA ROADMAP – Aligns with:

❑ TA07 Human Exploration Destination Systems / Advanced Habitat Systems;
❑ TA12 Materials, Structures, Mechanical Systems & Manufacturing / Structures;

PROJECT DEVELOPMENT SCHEDULE

FY '12

	1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
Project start			▲ 06/12	
Poster Session				▲ 08/12
Prototype development completed				08/12 ▲
Comparative Eval completed				08/12 ▲
Final Report				09/12 ▲

Project Start TRL: 1
Current TRL: 2

SINGLE-SIDED TEMPORARY ADHESION IN ZERO-G WITH GECKO AND ELECTRO-STATIC MATERIALS WALKING IN SPACE

PROJECT MANAGEMENT

ES2/George Studor
george.f.studor@nasa.gov 763 208-9283

JPL/Aaron Parness
aaron.parness@jpl.nasa.gov 818 393-2236

PROJECT OVERVIEW

- Demonstrate applications of new synthetic Gecko-feet and electro-adhesion materials to zero-G .

RELEVANCE/ VALUE TO NASA

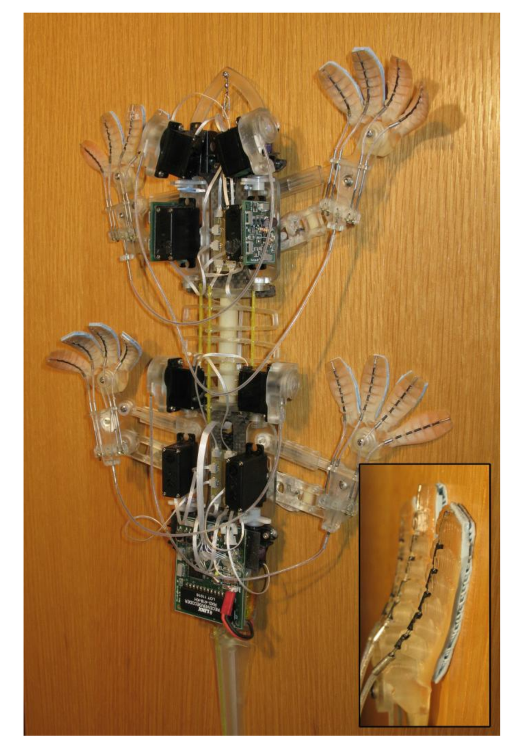
- Temporary adhesion can be controlled to keep items from floating away during crew ops, including the crew member.

OBJECTIVES & OUTCOMES

- Build and demonstrate a controllable mechanism to grip using Gecko-material secure sensors or equipment to a smooth surface, or to secure a crew member in a work area.
- Obtain and test an electro-adhesion pad to hold small articles in zero-g, provide ad-hoc adhesion for a free-flier and to potentially secure and astronaut to any smooth surface.

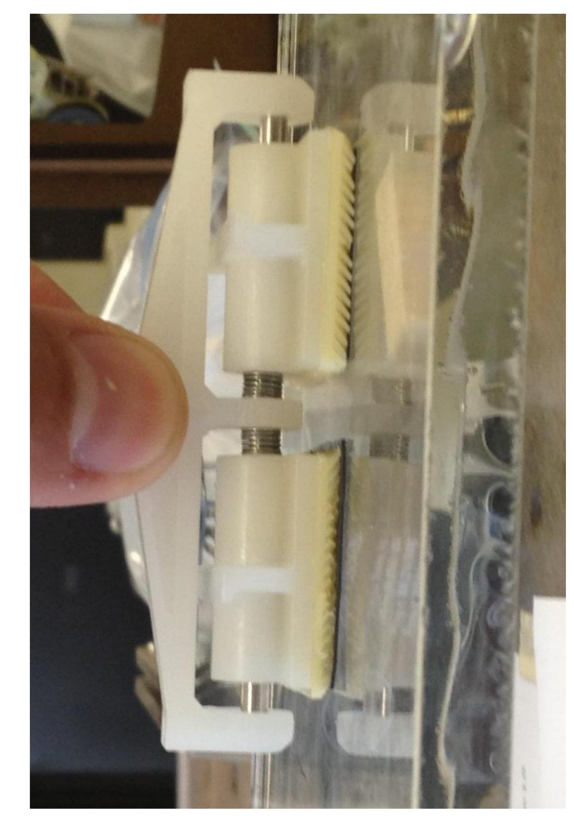
INFUSION POTENTIAL

- Additional characterization in ground labs and flight tests.
- Gecko-material pads could replace velcro in many applications and add functionality.such as attaching sensors
- E-A pads provide a portable surface to keep items, even food, from floating away.
- Both feed concept s of crew or robots maneuvering and/or securing themselves in place with min vehicle infrastructure in new vehicles.

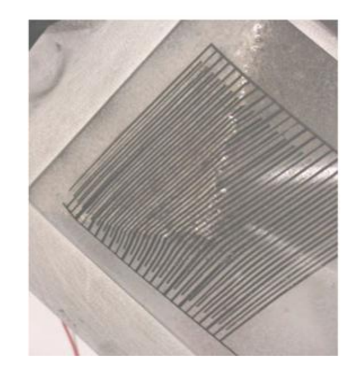


Gravity Assisted

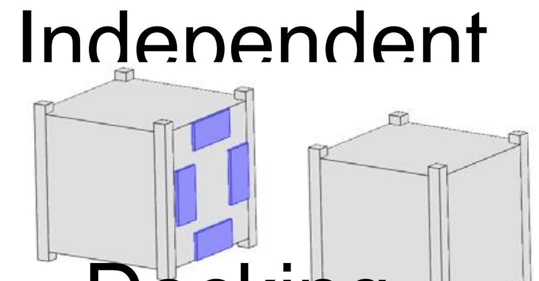
Synthetic Gecko-feet



Gravity Independent



Electro-Adhesion



Docking

E-A Climbing robot

IVA operations

NASA TECH AREA ROADMAPS

7.6.2 Construction and Assembly
7.6.3 Dust Prevention & Mitigation
7.4.2 Habitation Evolution
7.4.3 Smart Habitats
7.2.2 Maintenance Systems
12.2.5 Multifunctional Concepts
12.2.1 Lightweight Structures:
12.1.1 Lightweight Materials
12.5.1 NDE Evaluation and Sensors
12.3.4 Mechanisms Methods
12.3.1 Deployables, Docking, & I/F

FY '12

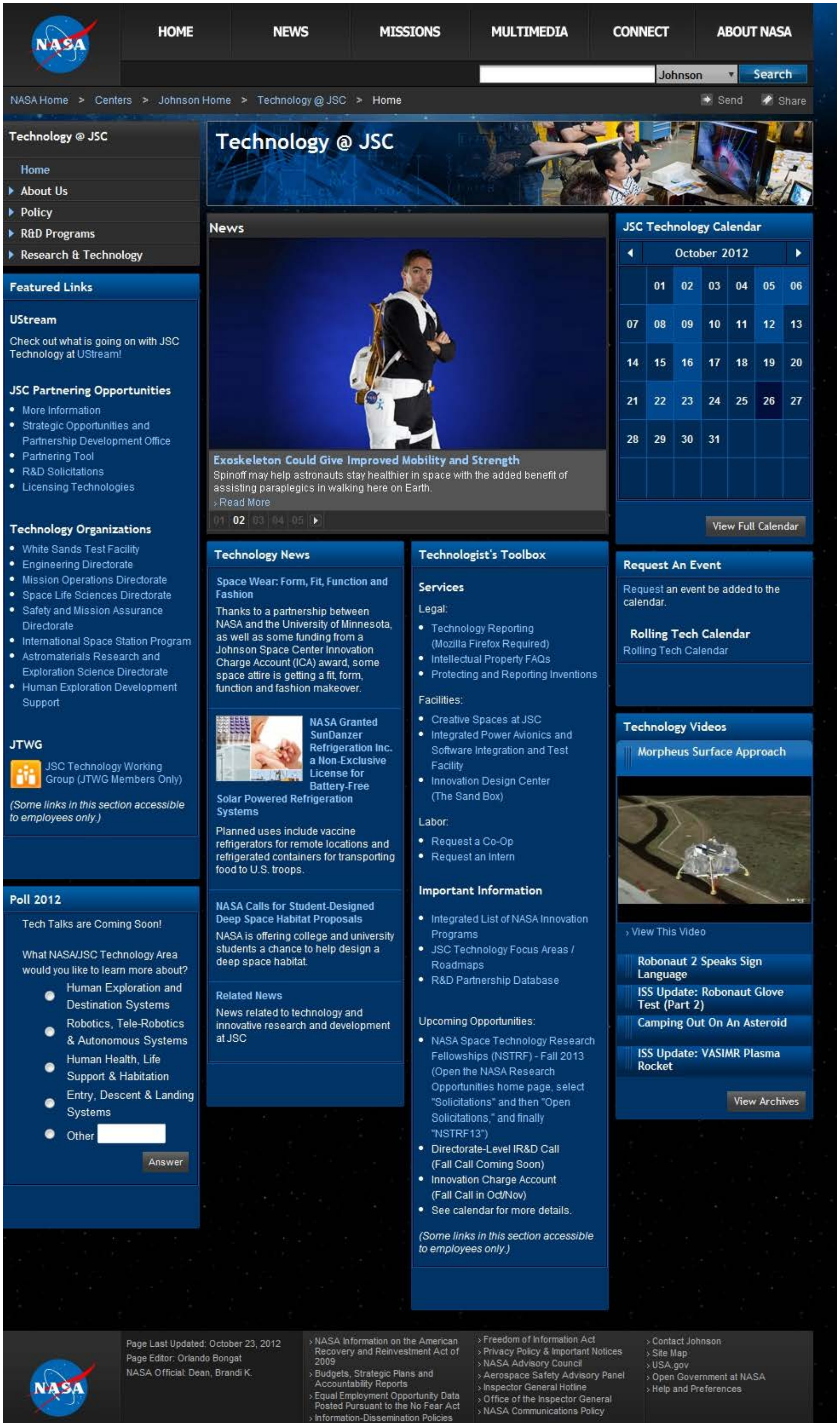
	1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
Project start			▲ 06/12	
Poster Session				08/12 ▲
Prototype development completed				08/25 ▲
Testing and Eval Completed				09/12 ▲
Final Report				09/25 ▲

Project Start TRL (1-9): 2
Current TRL (1-9): 3

Appendix D

Technology at JSC Homepage

Appendix D **Technology @ JSC Website Homepage**

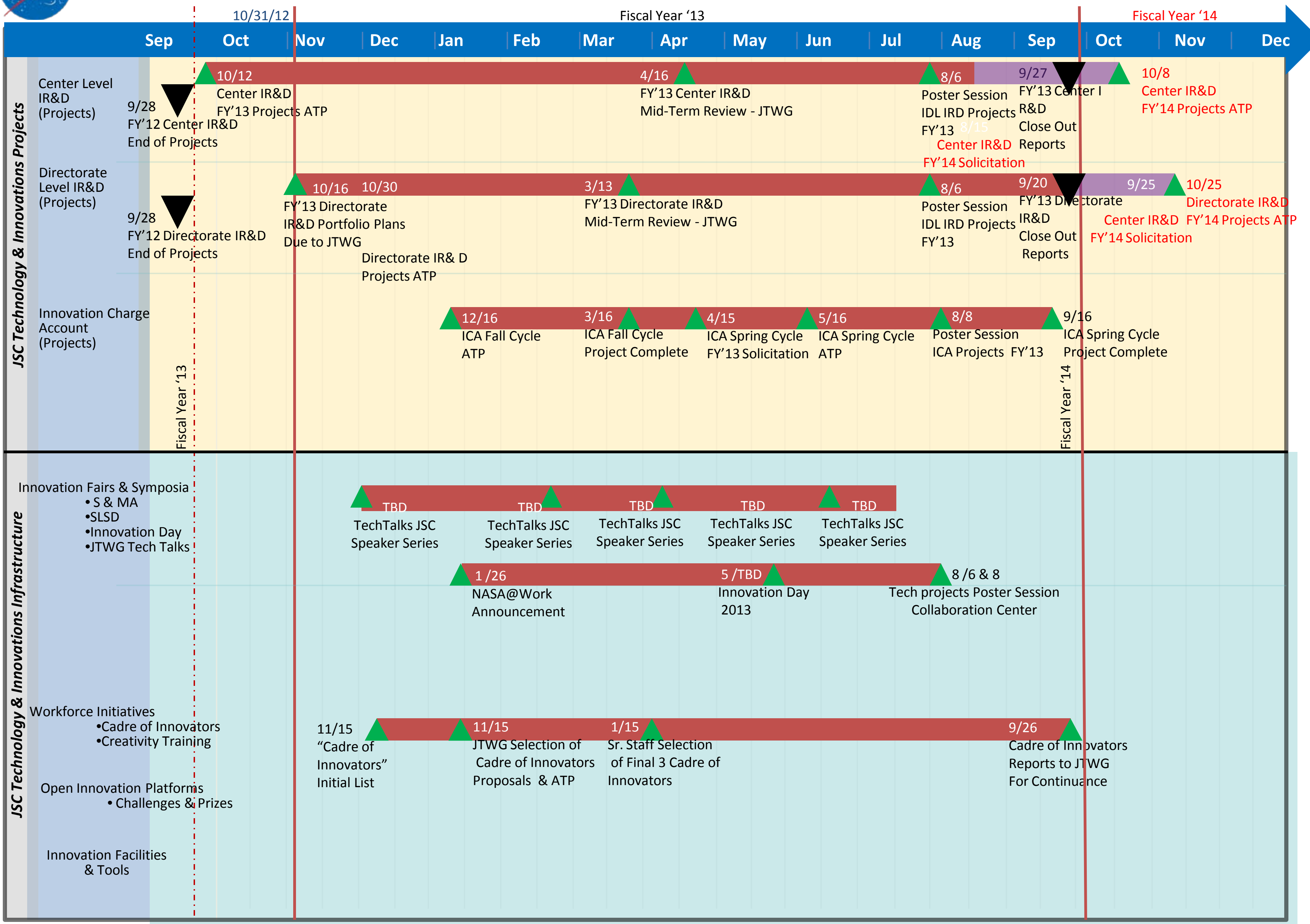


Appendix E

The Year Ahead / Technology Calendar FY’13 One-Pager

JSC Technology Development & Innovation Initiatives (FY'13)

Rolling Calendar
Rev. 2



P.O.C. John Saiz – Chief Technologists Office